AIR CORPS
UNITED STATES ARMY

ARCTIC MANUAL

VOLUME I

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Prepared under direction of the
Chief of the Air Corps

UNITED STATES ARMY

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By Order of the Chief of the Air Corps:

G. E. Stratemeyer,
Colonel, Air Corps Executive.

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CHAPTER 1

HISTORICAL BACKGROUND

SECTION I

GENERAL

To sketch a historical background for the Arctic, by listing expeditions and evaluating achievements, is beyond our scope; to do so would contribute little to the effectiveness of this Manual, the purpose of which is to present to Air Corps troops a broad and general view of the living and working conditions which they will encounter in Alaska and which differ so greatly from those to which most of them have been accustomed. But we feel we must at least outline the theories and beliefs which, from the time of the Greeks, have influenced thought and action with regard to the northern regions of the world. For many of these beliefs have been found both untrue and dangerous to the believer. We consider that the best way to learn how to protect oneself against the possible harmful effect of some theories still held by many is to have a grasp of all the more important ones and to understand rationally how and why some have been found correct while others have been found not merely incorrect but harmful.

SECTION II

THE CLASSIC VIEW

Powerful later in molding thought on the Arctic, the philosophical doctrines of symmetry came to Europe apparently by way of the Greeks and likely through the Pythagorean school around 500 B. C., if not earlier.

As applied to the earth, and then to the climates and their results, one of the main lines of argument was:

The earth is a heavenly body; the heavenly bodies are perfect; the most perfect shape is a sphere; the earth is

therefore spherical. The heat of the noonday comes from the sun (which, at an early Greek stage, was believed to be only a short distance up in the sky). It was considered that the lands of Greek civilization happened to lie at the right distance from the sun. It was sometimes unpleasantly warm or unpleasantly cold in Greece, but the average wasn't bad.

But if you went south from the Greek world, your approach to the sun would bring greater and greater heat. Finally you would come to the limit of human or animal endurance; beyond that you would die. Right under the sun, and for some distance on either side, the rocks would be red hot and the water, if any, boiling. This was the Burning Zone, the Torrid Zone.

Similarly, going north from the Greek world and getting too far from the sun, you would arrive where the cold was no longer endurable; beyond that you would freeze to death. This was the Frozen Zone, the Frigid Zone.

Said the Greeks: "Just as part of the world is uninhabitable underneath the sun because of the burning, so is it uninhabitable too far from the sun because of the freezing."

Through the doctrine of symmetry the Greeks felt it evident that there must be another livable, temperate zone south of the burning tropics and beyond this another frozen zone. That plants and animals existed south of the tropics was considered anything between very probable and certain; but it would remain a question of theory. For northern man could never cross the tropics south; men of the south, if any, could never cross them north.

Under this general view, which held sway from, say, 400 B. C. to after 1400 A. D., people of the north temperate zone were like rats in a revolving cage, free to move east and west, but imprisoned by a wall of flame to the south and of ice to the north. It was always theoretically possible to go around the earth east or west, and many thinkers took it for granted that someone sometime would do it. But that anyone ever would go around the earth south and north was absurd beyond discussion.

CONTRARY VIEWS

This, in outline, was the Doctrine of the Five Zones—two of them livable, three of them lifeless. It was what might be called the orthodox scientific view, corresponding, for instance, to the modern evolutionary concept in biology or to the Copernican theory in astronomy. There were many popular beliefs in contradiction, as, for instance, among the Greeks the idea that there were to the north the Rhipaean Mountains, from which cold winds blew, and beyond them a warm country, the land of the Hypoboreans, with golden fruit on the trees, unipeds, perpetual or protracted youth, a paradise beyond the cold. Such views the philosophers, scientists of their day, treated as folklore.

There were in circulation, too, from remote time stories that journeys had been done which would necessarily involve crossing the tropics, as, for instance, tales that the Egyptians had circumnavigated Africa. These were considered folklore. They were "obviously untrue"—they could not be true because the burning tropics could not have been crossed. The flaming zone was "known" to be such a short distance to the south from the Mediterranean that the length of the journey and the size of Africa, as described, became absurdities.

SECTION III

THE 1400–1845 VIEW

Those who like to personify revolutionary ideas and great deeds almost necessarily claim that Prince Henry the Navigator, beyond dispute a great man, was one of the greatest geniuses of all time. The argument runs that achievements like those of Columbus and Magellan are second rate, for they were only doing what thoughtful men in nearly or quite every century for 2,000 years had maintained that somebody would some time do. But Henry did what the same thoughtful men for the same length of time had "known" nobody could ever do.

Prince Henry of Portugal, and those who worked with him during the beginning of the fifteenth century, got the idea

somehow that the "burning tropics" might not be burning hot, that they might be crossable. Ship after ship of theirs went south, farther and farther along the west coast of Africa, many returning with what we now call an alibi, an explanation that they had gone so far that further progress would have been suicidal. But most of them returned, and others were therefore sent, until finally in 1471 Fernandez and Estesves went so far that the sun stood above their masts at noon. They returned to Portugal with the report that it had been no hotter right below the equator at sea than it sometimes is on shore in Portugal.

This final overthrow of the burning tropics came eleven years after Prince Henry's death, but was in continuation of the research which he started. It was scarcely more than routine thereafter for Diaz to reach the Cape of Good Hope in 1486 and for Da Gama to sail around it in 1497 to the Indies.

In the late fifteenth and in the sixteenth century voyages across the tropics grew common, both for reaching the south temperate zone and for circumnavigating Africa and South America. Fabulous and grotesque beliefs about the tropics were now too frequently checked against reality and began to decrease. They have decreased steadily since, until there is today among most temperate zone people almost as rational an attitude toward the tropics as there is toward home countries. Besides, many of our civilization now live in the tropics. Common sense has therefore had sway for a long time over the whole region that extends between the northern and southern polar zones.

The conquest of the polar districts, whether by actual travel or in the thought of our people, has been in comparison with the tropics a slow matter.

At one time it was the Greek orthodox view that to the north of them lay, extending east and west through what we now think of as the middle territories of the Soviet Union, a line beyond which no human or animal life could go because of the cold. Farther west this line was at one time considered to pass just north of the north tip of Scotland.

LIFE BOUNDARY MOVES NORTH

But some time before 795 A. D. the Irish discovered Iceland; by that date they were living in Iceland the year round. This pushed the southern boundary of the region of universal death some 600 miles north of Scotland.

Between the tenth and twelfth centuries the Icelanders (of Norse and Irish descent) who colonized Greenland, went up along its west coast at least 20 miles north of Upernivik, where their most northerly runic monument has been found. They probably reached Smith Sound, according to Rasmussen's conclusions from Smith Sound Eskimo studies, which were confirmed later archaeologically.

The Upernivik monument is more than 350 miles north of the north tip of the Arctic Circle; the Smith Sound archaeological finds are some 200 miles north of Upernivik, nearly 600 miles beyond the Circle. Besides, either by the Dutch in 1596 or earlier, Europeans reached Spitsbergen, which through the spectacular development of the whale, seal and walrus "fisheries," was soon cultivated by large fleets. The seas roundabout were known well north of the north tip of the Svalbard archipelago, to nearly or quite 1,000 miles beyond the Circle. The realm of frozen death was shrinking.

To the student of the history of European thought, it is striking about the northward movement of the white race on the Atlantic that the great pioneers, the Irish, Norwegians, Icelanders and Greenlanders, were unaware of the theoretical northward limit of human and animal life which had been set by Greek cosmography. But later explorers, who had been indoctrinated by southern philosophy, particularly those of the eighteenth and nineteenth centuries, believed consistently that there was somewhere a northern limit; and were uniformly surprised, startled and bewildered when they discovered at least some life wherever they went. But they usually "knew" that at their farthest north they had been at the farthest outpost of life; and that beyond all would be dead.

EXPLORATION MOTIVES IN 15TH CENTURY WERE COMMERCIAL

However, during the revival of exploration which followed Columbus, trade motives were supreme, or the desire to spread Christianity. It was therefore as pleasing as it was surprising to find life far north, for this implied resources and even riches. So explorers received compensation for their voyages, glory upon their return, in proportion to how they reported either discoveries of wealth or the prospect of such discovery. Particularly was it advantageous to report or make seem probable the existence of people—traders would later profit by them and priests convert them. Greatest of all desires was the finding of a near seaway to the wealth of "the Indies."

Swayed by a compelling desire, Europe changed its thinking after Columbus. The earth remained spherical. European countries were north of the tropics; so were the Indies. In consequence, the shortest route between Europe and the Indies must lie northwest, northeast or north.

Wish being parent of thought, it was assumed following Columbus that if there were an Arctic ocean it would be crossable. The view persisted for centuries.

Those explorers were now most readily believed who made the most favorable reports and indulged in the rosiest speculations. Their attitude persisted, although somewhat on the decline, until there came a full stop through the tragedy of Sir John Franklin. Two ships, great for that time, sailed in 1845 with 129 men, some of them from the "best" families of England. Not one of them ever came back. For years the place and manner of their loss was unknown. When knowledge came it showed that not only had they starved to death but that they had eaten each other—when some were already dead of hunger their comrades ate them and then also died.

SECTION IV

THE VIEW SINCE 1845

The shock to the world of the Franklin tragedy put a full stop to that hopeful commercial era of northward exploration which began with Columbus.

There were two elements in the changing attitude following 1845:

One was the change from the commercial motive toward a sporting one; particularly there developed an analogy to mountain climbing. Because wall maps are customarily suspended with the north side up, there grew the idea of the North Pole as the top of the world. The "attainment of the Pole" held the same lure that the topmost peak of Mount Everest has for alpinists. There were subsidiary reasons for the analogy between the Pole and the top of a mountain. Both were thought of as snow-covered or ice-covered. The North Pole was assumed to be in the center of a vast ice cap and to be, as a result, the hardest point in the Northern Hemisphere to reach. Therefore, whoever attained it would be the first in history to reach the equivalent of the top of the world's supermountain—with corresponding views about the South Pole and its attainment.

The other element in the changing attitude following 1845 was that the reports of travelers now tended more to the exaggeration of dangers and difficulties than to the exaggeration of the ease and safety of travel. Those were hereafter more readily believed who emphasized or magnified difficulties. Consciously or not, the ambition of the explorer was no longer to be a pioneer but rather to be a hero. Finally this was sublimated into a desire to secure and report scientific results, usually with background and trimmings of heroism and sacrifice.

This attitude toward the North, with its blending of sport and heroism, has persisted. There is a further blending in that many of the classic Greek theories are now much in evidence. The resulting point of view, a combination of folklore, heroism, and sport, is familiar to all of us from the narratives of explorers and from our schoolbooks; it has become a part of our accepted knowledge.

The following chapters are intended to present to the reader the Arctic as it really is. As best we can we shall strip from it the exaggeration of its dangers and difficulties. Then we shall attempt showing how to deal with such dangers and difficulties as are real.

CHAPTER 2

PHYSICAL GEOGRAPHY

SECTION I

LAND: TOPOGRAPHY

First of the northern subdivisions we consider Greenland; for it is at once most like what all Arctic lands were believed to be and most unlike what they really are.

GREENLAND

In the sense of land differentiated from ice, Greenland is considered to be low in its center, with mountain ranges along both western and eastern coasts. The western range averages perhaps 7,000 feet, running to 8,840 feet at Camp Watkins; the eastern reaches heights of 9,000 to 11,000 feet, with the probable maximum at Mount Forel, 11,500 feet.

Glaciers have filled the central land depression, flowing east from the western range and west from the eastern, till the basin is more than filled—has a flattened dome outline, somewhat higher in places than any but the extreme peaks of the eastern range.

At stations 300 to 400 miles inland from the east and west coasts respectively, measurements have been made by echo-sounding which show such ice thicknesses as 8,800 feet where the surface of the ice is 9,800 feet above sea level.

Greenland is, then, for practical purposes a turtle-backed island continent, 600 to 800 miles wide generally and more than 1,600 miles long, with a maximum height of the turtle-back which is probably around 10,000 feet and with few if any passes across from east to west that are less than 7,000 feet high. The "divide" from which the ice slopes east and west,

is an irregularly curved line running generally north and south somewhat farther east than the middle of the ice dome.

The coasts are the most rugged in the whole Northern Hemisphere, well beyond the Norwegian or even the Icelandic. Every valley is a path for seaward glacial flow, although the glaciers may not reach the sea. In a few cases it is more than 100 miles from the coast to the nearest land ice. If this be remembered, a topographic map of Greenland, such as published by the Geodaetisk Institut, Copenhagen, gives the rest of the description—except that we should describe the ice slopes.

Because Greenland is the one northern land heavily glaciated we reserve for the Guide Book of Greenland a detailed discussion not only of the Inland Ice and its technique but also of crevasses and the technique of ascending and descending a crevassed slope. However, we place here a few notes on glacier slopes. (See also Section IV, Chapter 11, of this volume.)

At distances reported to vary between 15 and 100 miles from the seaward edge of the ice its flow towards the coast is speedy enough to form crevasses. Some authorities say that these become more numerous the closer you are to the seaward edge; others say they are most numerous where the slope is steepest. In any case, crevasses are usually numerous near the seaward edge and are numerous on all steep gradients. It has been reported frequently by parties ascending glaciers that after passing a belt of crevasses another belt free from crevasses is traversed and then a second and later other belts.

The crevassed belt is wider back of a valley through which the glacier is going to flow than back of higher coastal land that tends to obstruct the flow. Crevasses extend farthest inland behind those fjords which have the most rapid ice flow—gaps in the coastal mountains which are the widest and deepest gates for the exit of the Inland Ice.

WIDTH OF CREVASSES

The reported gaping width of a crevasse at the top varies from less than 10 feet to more than 60. That narrow cre-

vasses are seldom reported is because a narrow gap will be bridged over by snow which usually is strong enough to support men and dogs, and which might support taxiing airplanes but of course not a tractor.

Crevasses are both produced and widened by flow motion of the ice; they are further widened in spring and summer. For the direct sun, the warmth of the air and the action of running water unite in turning them practically into valleys toward the end of the warm season. Each of these valleys will naturally fill with snow the following winter, whereupon they cease to be crevasses from the point of view of travelers—the snow will be packed so hard that there would be no danger to sledges or taxiing airplanes and no source of catastrophe, although perhaps of difficulty, to a heavy tractor.

Crevasses are usually at right angles to the direction of ice flow and seldom extend more than part way across a valley, so that each in its turn can be gotten around by zigzagging right and left.

Because of the crevasses and their "treacherous" covering of snow, it is dangerous to sledge or walk up or down in winter, since you and your team, tractor, or taxiing airplane may fall through without warning and to a depth which would normally be fatal for men and animals—the like even more probably true for tractor or plane, except that a plane likely would hang suspended by its wings.

TRAVEL PRECAUTIONS

In climbing or descending a glacier, men should be roped together alpinist-fashion, the distance between them being greater than the greatest width of a crevasse that can be bridged by drifting snow. There is, however, no agreement on how wide such crevasses could be. Probably a distance of 20 feet between men advancing at right angles to the crevasses would be sufficient. For like safety purposes dog teams can follow each other with the harness of the leading dog of one team attached by a rope to the sledge next preceding. It should not happen on the ascent of a glacier that more than one dog team falls into a crevasse, where they would be suspended each in his own harness. The danger

is considerably greater descending a glacier slope, for if a leading team falls through it will be difficult for the teams and men behind to hold back. What you do is turn the teams sideways and upset the sledges to stop them from sliding.

In summer the crevasses are not hidden, for the snow has been melted away, but they nevertheless form a very serious handicap in going up or down.

EXTENT OF SNOWFREE LAND

No doubt because of a combination of high mountains and a heavier precipitation, there is comparatively little snowfree coastal land near the south tip of Greenland; it is correspondingly true that because of small elevation and light precipitation there is a large section of mainly snowfree land at the north tip of Greenland, Peary Land. The widest sections of territory free from snow in summer are at distances between 200 and 500 miles northward from Cape Farewell along the west coast of Greenland (between about Latitudes 63° and 68° N.) and on the east coast at and north of Scoresby Sound (between Latitudes 70° and 74° N.). These and the wide glacier-exempt stretches of Peary Land have been known for a long time.

In recent years we have found that the Peary Land snowfree areas are even larger than believed and that there are "surprisingly large" icefree lands in northeast Greenland. Elsewhere on these coasts there are narrow snowfree coastal strips broken here and there by glaciers which reach the sea. On the west coast there is one long stretch practically without snowfree coastal land which extends from about 74° N. Lat. to about 77°.

Around 1920 it was estimated that 84 percent of Greenland was covered by ice; but each new exploration usually shows "unexpected" snowfree land, and it seems in 1940 that the iced parts of Greenland will prove to be not over 80 percent. This will mean that every summer there is more snowless country in Greenland than in Great Britain and Ireland combined, or more than in the New England states, with New York, New Jersey, Delaware, and Maryland added.

GLACIERS

We have described for Greenland a proper ice cap. There is no real ice cap in any other Arctic land; there are glaciers in some of them, but only if they are mountainous. Roughly the height of mountains required for glaciation varies inversely with the precipitation. Latitude does not seem to be an important factor in glaciation when you are once north of 60°.

As we said about Greenland, the section we now treat, Arctic Canada, Alaska, and Siberia, are fully covered in the respective Guide Books and we give here the briefest sketch only.

CANADA

As we go west and southwest from Greenland the glaciers decrease rapidly. The biggest ones, no doubt, are in Ellesmere Island, which is rugged; but it is possible that glaciers equalling them are to be found in Heiberg Island. North Devon has smaller glaciers and Baffin Island still smaller. There are no proper glaciers, but at most an occasional snowbank hidden from the sun in a deep ravine, when you go westward through the island tier to which Baffin Island belongs—Somerset, Prince of Wales, King William, Victoria, and Banks. It may be that some of these do not have even a small snowbank left anywhere toward the end of summer.

In the tier west from Devon—Cornwallis, Bathurst, Melville, and Prince Patrick—there are somewhat more numerous snowbanks that persist, for these islands are more rugged. In Melville Island, properly mountainous although the highest peaks may not be more than 4,000 feet, the name glacier has been applied to a few large snowbanks, particularly back of Liddon Gulf and Murray Inlet. No one has been in Prince Patrick Island during the summer to tell whether it has persisting snowbanks—likely there would be a few of considerable size, though hardly to be called glaciers.

In the tier west of southern Ellesmere—Amund Ringnes, Ellef Ringnes, Isachsen, Lougheed, Borden, and Brock—there are snowbanks at the end of summer but almost certainly none as large as those of Melville.

There remains a small island at 80° N., 100° W., Meighen. This was reported by Stefansson to have, when viewed from the sea, a flattened dome skyline of such a kind that he thought it might have an ice cap—if you would name as a cap a shield 15 or 20 miles in its greatest diameter. There is, however, a chance that this island has, in proportion to area, the largest amount of land ice found anywhere between Greenland and the Beaufort Sea.

There are no mountains in continental Arctic Canada, and therefore few or no persistent snowbanks, until you come to the very northwest, Yukon Territory, where a few small glaciers have been reported in that territory's real mountains. However, the permanent snow in Arctic Yukon is almost certainly much less than 10 percent of the permanent snow in the non-Arctic part of the same territory. On the whole Yukon is a mountainous region with peaks running up to 8,000 feet.

The greater part of mainland Arctic Canada, outside Yukon Territory, is prairie land.

ARCTIC ALASKA

In Arctic Alaska the Brooks Range separates the waters flowing southward into the Yukon, or westward into Bering Sea from those flowing northward into the Arctic Ocean. Although spoken of as a unit, this range consists of many individual mountain groups—the De Long, Baird, Schwatka, Melville, and Endicott toward the south; the Franklin, Romanzof, Shublik, and Sadlerochit groups toward the north.

Compared with other Alaska ranges, the Brooks is relatively low, with a few peaks between 7,000 and 10,000 feet high.

In the range, west of the meridian 150°, Smith and Mertie report that while glaciers were formerly extensive they are uncommon now. Leffingwell found near meridian 146° that there were no proper glaciers in the 5,000- or 6,000-foot mountains visible from the coast, but that there were glaciers of some size a little farther south where peaks run up toward 10,000 feet.

Although the height of the peaks and ridges makes them formidable barriers to travel, there are many gaps at lower elevations—both east-west and north-south—by which passage of the mountains can be made with reasonable facility.

COASTAL PRAIRIE

North of the Brooks Range is a triangular prairie. It is only 15 or 20 miles wide, from the sea to the rugged foothills, at the Alaska-Canada boundary; it reaches a 200-mile north-south width abreast of Barrow, and disappears near Lisburne. You find most portions of this prairie so level, when you are near the sea and east of Barrow, that it is difficult or impossible for the unaided eye to judge which way it slopes; but if you follow a river inland you notice readily that the territory along it is getting higher and higher. First you are in rolling prairie and then you get into proper foothills. But west of Barrow, although not quite at Barrow itself, the land tends to increase in altitude more rapidly and perceptibly from the coast.

NORTH COAST OF ALASKA SINKING

In attempting to utilize the north coast of Alaska for any sort of supply depots, or bases of operations, it must be taken into consideration that this coast is sinking rapidly.

So long as the sea ice remains in winter and spring, nothing happens to the injury of the islands off the north coast; but when the ice goes away, as it does nearly every summer, and when a gale comes from the open sea, the waves will undermine the cliffs of the islands at a great rate, so that the coastline sometimes recedes as much as a hundred yards in a single summer. An instance of how coastal islands disappear is Flaxman. When the early whalers came to the eastern north coast of Alaska in 1889 this island was probably some 8 or 10 miles long. Thirty years later it was no more than half that length, having also narrowed correspondingly.

What happens to north coast islands is happening to that coast itself, especially where unprotected by off-shore isles and reefs.

SIBERIA

Generally speaking, the coast of Arctic Siberia resembles that of Alaska, although mountains come near the coast at places which are less regular. The mountains are not far

inland between Cape Dezhnev (East Cape) and Serdzekamen. Thence westward to and around Kolyuchin Bay the land is low, but mountains are not far from the coast at the western edge of the bay. Then comes lowland extending for several hundred miles to Cape Severny. From there the low plain is rather narrow, and high land is visible when you look south from the coast till you approach the Kuvet River; then, after a narrow patch of lowland, you find it high inland again to Cape Shelagski. Back of Chaun Bay there is a good deal of lowland, the practically joint valleys of several rivers. High land is usually visible toward the interior west of that bay till you come to the eastern edge of the Kolyma.

The mountains begin to recede from the coast once the Kolyma is approached; and also to decrease in height. In central Siberia lowland, forest or prairie, is found in the drainage basins of the western tributaries of the Kolyma, and in those of the eastern and western tributaries of the Indigirka. The mountains do not approach the sea closely again until the Yana is reached. The highest land in this district is Tomuskaya Mountains, east of the Indigirka, which taper off into Alazeya Plateau.

West of the Yana, the mountains once more recede to considerable or great distances from the coast; the land is mainly prairie with great northward-flowing rivers—the Lena, the Yenisei and the Ob, and several others of less length and smaller drainage basins. Along these rivers the evergreen forests stretch far north beyond the Arctic Circle—more than four hundred miles on the Yenisei to tidewater on the Lena. The Ural Mountains constitute the only high break in this country.

No glaciers are found in the vast extent of mainland Arctic Siberia. Some large areas are also free of persisting snowbanks, as we described for Arctic Canada. Where there are mountains, chiefly in the northeast, descriptions apply such as those we used from Leffingwell for the Canning River district of Arctic Alaska.

With the exception of Wrangel, the islands of the eastern Asiatic section of the Soviet Arctic are comparatively low and none of them contain permanent snow. Herald Island

is almost a solid mass of granite, nearly or quite 1,000 feet high. Wrangel has a mountainous plateau traversed by two longitudinal ridges and several deep-cut valleys. The highest point is about 2,500 feet, but no glaciers are found. The New Siberian Islands, which lie a considerable distance west of Wrangel have greatest heights between 1,000 and 1,200 feet.

Proceeding westward we find the first glaciated areas at Severnaya Zemlya. Approximately 45 percent of the entire area of this island group is covered with ice fields from which glaciers descend to the coast. The interior has plateaus 1,300 to 2,000 feet high. Novaya Zemlya is an island in two main parts. Its northern section, running down to approximately 75° N. Lat., is largely covered with ice, with average altitude of nearly 2,000 feet, the highest peak reaching an elevation of some 3,000 feet. The highest sectors of a mountain range, which stretches from north to south, are in the central portion of the island, where the glaciers begin to disappear. In this section the highest elevation is 3,350 feet. The land south of 72° N. Lat. is generally low and flat.

The reason why the highest part of this island has little ice is considered to be that as you go south along the island you get away from the ice-making, because precipitation-encouraging, influence of the warm ocean current that sweeps east and northeast around the north of the Scandinavian peninsula and of Novaya Zemlya.

Vaigach and Kolguev Islands, south and southwest of Novaya Zemlya respectively, have no glaciers and no permanent snow. Most of Vaigach is swampy and filled with lakes, but there are two ranges of hills stretching from one end of the island to the other which reach an elevation of 300 feet in the center. The northwestern part of Kolguev Island attains 425 feet but the southeastern section is flat, only a few or a few dozen feet above sea level.

In the northernmost and westernmost section of the Soviet Arctic lie the group of islands known as Franz Josef Land. They are mainly ice-covered plateaus, rarely more than 1,000 feet high with the exception of Cape Tirol, on Viner Neishtadt

Island, which is near 3,000 feet. Frequently the snow line comes down to 300 feet, the only bare area of considerable size being on Alexandra Land.

Many shores of these islands are ice covered; but where there is no ice they exhibit a terrace formation with elevations ranging from 100 to 400 feet.

SVALBARD ARCHIPELAGO

Between Novaya Zemlya (Soviet territory) and Greenland (Danish) lies the Norwegian Svalbard archipelago.

The chief island, Spitsbergen, is a much dissected plateau with many deep fjords penetrating far inland. Small plains are found in the north and west. Sharp peaks rise to 4,960 feet in Horn Sunds Tinder in the south, 3,450 feet in Mount Monaco on Prince Charles Foreland and 4,770 feet in Mount Eidsvoll in the northwest. In the middle and east the mountains are flat-topped and seldom over 2,000 feet; Mount Newton, 5,445 feet, in New Friesland, is the loftiest peak in the archipelago.

Glaciers fill the valleys except in the southern interior where they have receded; they generally reach the sea, often along broad fronts, but give rise to no large icebergs. An ice covering over New Friesland is the nearest approach to an ice sheet in the Svalbard group. Barents and Edge Islands have glaciers only on the east. The Wiche islands have no large glaciers, but North-East Land and Giles (Gillis) Land are each covered with a dome of ice that almost envelops them. Prince Charles Foreland has numerous glaciers.

Isolated Bear Island, a part of administrative Svalbard therefore remote from (south of) the Spitsbergen group, rises to 1,630 feet in Mount Misery. The northern part is a plain at an elevation of about 150 feet. There are no glaciers.

ARCTIC LAKES

For travel purposes it is to be remembered that land which is described as flat will usually have from 40 percent to 60 percent of its surface represented by lakes of various sizes. Most of them are shallow and some of them so shallow that a man can wade across by a lake's greatest diameter that

may be one or even several miles. This shallowness of lakes is important to remember in connection with pontoon or flying-boat descents; but it is equally to be remembered that if the keel of your pontoon or boat were to touch lake bottom it would be, in nine cases out of ten, soft and slippery mud. For below the water of shoal lakes the "eternal frost" will thaw for several feet, although on the prairie between the lakes it will thaw only as many inches.

In rolling Arctic country there will be fewer lakes than on the flat lands, although a considerably larger number than we expect on such a terrain in other zones. It is only in very rugged districts, practically mountainous, that the proportion of lakes to the rest of the country is about the same in the Arctic as we would expect in temperate zone or tropics.

When the land is flat and the lakes most numerous, some of the lakes will have no outlet; many of these will connect one lake with another by sluggish streams. In rolling country, lakes are connected with each other, or not, about as they would be in the temperate zone; and the same, of course, is true for what few lakes there are in rugged country.

The proportion of rocky land is less in the Arctic than in the other zones. The chief reasons are, no doubt, those of erosion. Because of the permanent frost that prevents underground drainage, land is seldom dry enough to permit winds blowing it away. Because the rainfall is light there is little water erosion, except the described breaking of coasts by the sea.

GROUND FROST AND GROUND THAW—GENERAL PRINCIPLES

Ground frost is related to several of the Arctic and sub-Arctic problems with which this Manual deals. It has an important bearing on European-American community life in the North, and is of perhaps even greater importance in connection with road construction, aviation, the use of tractors, etc. We place here our chief disscussion of the problem and refer back to it later when we deal with the topics in which it plays a part.

A light on the interplay of ground frost and ground thaw comes from studies of water at sea and in lakes.

If at a given very low temperature you have at sea five inches of young ice forming the first 24 hours after a lead opens, then 4 inches may be added the second 24 hours, three inches during the third twenty-four, and so on; until after say 2 weeks the daily increase of thickening is a fraction of an inch, and continues decreasing.

This is on the assumption that no snow has fallen. Should there fall a blanket of snow, the speed of freezing decreases immediately. It is probable that under an average snow blanketing a foot thick the entire freezing of an Arctic winter would not produce more than 6 or 7 feet of ice. A heavier blanketing would keep the ice still thinner.

Sea ice gets crusted on top with salt, is never slippery, and therefore always has a certain snow covering, so that freezing in one year to a thickness of more than nine feet probably never occurs. (By breaking and superimposition, sea ice under pressure may become 200 feet thick.) Fresh water ice is glare, large patches remain uncovered with snow, and there the thickness of freezing may be as much as 15 feet.

But the principle is always the same—you arrive finally at a point where the thickness of the ice itself gives so much insulation from the weather that no more water congeals on the under side of the ice. Its maximum thickness has been attained.

On land in the sub-Arctic districts, where there is no permanent ground frost, nine feet may be the maximum depth to which the winter frost of any year penetrates. This would be where the ground is swept clear of snow by the wind. There are few such places, only those without vegetation and with a smooth surface.

But for reasons upon which geologists do not as yet agree there is permanent ground frost in nearly the whole Arctic and in a considerable part of the north temperate zone.

LAND BENEATH A GLACIER USUALLY OR ALWAYS UNFROZEN

A theory for ground frost which no longer appears tenable is that it is a "relic of the Ice Age." For, logically, the frost goes down to that point where a balance is reached between the earth's interior heat and the chill that has penetrated

down into the crust from the atmosphere. Now if you have, above the topmost layer of proper earth, a layer of ice perhaps thousands of feet thick, such as there now is in interior Greenland, then you would think that the point at which a frost line balance was reached between the atmospheric cold and the earth's interior heat might be very near the underside of the ice. Recently this has been proved true in at least a considerable number of special cases. Where glaciers are retreating, pits have been sunk into the earth and it has been found, in most if not all cases, that the earth beneath the glacier had been unfrozen.

According to recent geological findings, there were great areas of land in the Far North not glaciated during recent Ice Ages, no doubt for the same reason (elsewhere explained) that keeps northernmost Greenland free of permanent snow. The northern plain of Alaska has always been free of glaciation, so far as geologists have yet discovered. When the front of the ice was perhaps as far south as New York City the winters must have been long and intensely cold on the nearly snow free prairies south from Point Barrow. That was the time, no doubt, and those were the circumstances under which the frost penetrated so deep that even today the north Alaska ground frost line, balanced against the interior heat of the earth, is several hundred feet down.

Ideas on the geographic extension of frozen subsoil are being altered in recent years. Textbooks are still in use which would indicate that perhaps a third of all British North America, continental and insular, had frost beneath the surface. Railway construction engineers have pointed out, however, that they encountered permanent frost at one or more points on the north shore of Lake Superior while the more northerly right-of-way of the Canadian National back of Superior encountered still more frost. There are, near the southern limits, islands of frozen ground surrounded by large areas without frost. As you go north the situation changes and you have islands of thawed ground in a generally frozen district. It would appear a conservative guess, if you allow for both types of islands, that 50 percent of all British North America has permanent ground frost. A likelier guess is 55 percent.

Generally speaking, frost goes well south in British North America, chiefly east of the Red River of the north. In the prairie provinces the southern limit of frost runs northwesterly so that it is most southerly in Manitoba, intermediate in Saskatchewan, and farthest north in Alberta where the limit of sporadic occurrance is probably not far from Lesser Slave Lake. It may be equally far north in British Columbia. In Alaska there seems permanent ground frost in all land north of the Brooks Range. The Yukon drainage basin is mainly frozen. South of the Alaska range divide much land is unfrozen.

GROUND FROST IN SOUTHERN ALASKA

Ground frost has been reported from the Cook Inlet-Susitna district where there are islands of frozen subsoil. Where there is thick moss, ice is not infrequently found within 40 inches or less of the surface, but elsewhere its presence that near the surface is exceptional. Ice is common within 3 feet or less of the surface between Montana and Willow Creeks and was found within about a foot of the surface along the banks of the Susitna River, near the mouth of Willow Creek, in August.

GROUND FROST IN SIBERIA

Perhaps because heavily ice-covered in glacial times, there is "surprisingly" little ground frost in northern European Russia. But the Soviets, mainly in Siberia, have a far larger total area of frozen ground than does North America. There, as with us, the known limits of the ground frost are being moved farther and farther south the more complete the exploration. An approximation of the southern boundary was made in 1939 by Professor George B. Cressey, of Syracuse University. He considers that on the Pacific side the permanent frost occupies the northern half of the Kamchatka Peninsula as well as all land to the north. West of the Okhotsk Sea the frozen ground pretty well follows the coast south until you are abreast of Sakhalin Island. Then the frost trends inland; somewhat west of Khabarovsk a tongue of it extends a little farther south than that city, or about to the latitude of

northern Lake Superior. West of there the frost in some places goes a little south of 50° until you are abreast of (south of) Lake Baikal. Then it trends northwesterly, keeping mostly to the east of the Yenisei River, and runs northward to about 65° N. Lat., where it crosses the Yenisei and trends westerly, coming to an end, or practically so, on the shores of the eastern White Sea. Altogether, he estimates that permanently frozen ground underlies 3,728,900 square miles of Soviet territory.

PROBABLE TOTAL FROZEN AREA

Northern hemisphere lands underlain by "eternal" ground frost may have a total area equal to not much less than that of continental North America from the Rio Grande north.

DEPTH TO GROUND FROST

Specific figures on the depth at which ground frost begins were used for named localities and described conditions in southern Alaska because this Manual is more likely to be used in Alaska than elsewhere. Speaking generally, we may say that frost islands are discovered usually at a depth of from 7 to 11 feet near the southern limit of their range. Around Great Slave Lake, Canada, the frost may be discoverable at 3 feet. In the forest just north of Great Bear Lake or on the lower Mackenzie, as around Fort Macpherson, there is practically no thawed ground—all that thaws out in several weeks of weather so warm that people complain about it is the leaves, branches, and muck. North of the forest, however, where the sun gets more direct play, the thaw will be deeper again; so that even a hundred miles north of the treeline the thaw may go 2 or 3 feet down, especially on southward slopes that are sandy. A similar slope if covered with swampy meadow will thaw to 8 or 10 inches. Level land on the north coast of Canada and Alaska is thawed in August to depths of between 6 inches and a foot. The like is true for prairie in the islands to the north of Canada.

SPECIAL CAUSES OF THAW

Geologists have reported thawed ground extending to an indefinite depth in some parts of Alaska where frozen ground is nearby. It may be that in at least some cases the observers did not realize a special factor—that Arctic rivers, and even lakes, will remove permanent frost from the ground for a considerable distance. The ocean does the same. On the north coast of Alaska, where the sea is advancing upon the land, the thaw produced by the sea will on a gravelly coast precede the advance of the water, according to different reports, from a hundred feet to a hundred yards. Where the sea coast is muck or ground ice the thaw does not precede the advance of the sea—the frozen outbanks are thawed and sloughed away by the direct attack of the waves.

THICKNESS OF GROUND FROST

In some Arctic districts shafts have been sunk more than 200 feet without going through the permanent frost. The whole subject has been so little studied it is scarcely worth speculating what the maximum depth of ground frost may be.

With regard to the bearing of ground frost upon the location of towns which expect to carry on in a more or less typical "civilized" way, the important point is to study the exceptions to the rule. Northern lands are not everywhere permanently frozen. (See section I, chapter 7.)

SECTION II

SEA: TIDES, CURRENTS, ETC.

The Arctic "Ocean," with its 5,000,000 or so square miles, is tiny when compared with a real ocean. It is, say, one-thirteenth the size of the Pacific; it is not over one-seventh as large as the Atlantic, from which it is a gulf. It does look like an ocean on Mercator charts, which manify it grotesquely. Viewed in true proportion, as on a globe, the Polar

Sea is a mediterranean that separates Eurasia from North America somewhat as a smaller mediterranean separates Europe from Africa.

This relatively small north polar basin has on its margins a continental shelf, wide in most places when compared with shelves in the rest of the world, and, indeed, conspicuously narrow only toward Alaska.

By ordinary definition, continental shelves have upon them water 200 meters (656 feet) or less in depth; the Arctic shelf, while it is still a true one in the sense that eventually it is going to descend rapidly to great depths, is likely to have on it water of 300, 400, or even 500 meters, as we shall see when we come to a description of particular segments.

Nor is the polar sea uniformly surrounded by a shelf of even these greater depths. There are still deeper openings, or gates. For instance, in Baffin Bay we have depths falling below 6,000 feet; in the Greenland Sea they fall to twice that depth; Barents Sea (sometimes thought of as a gulf of the Greenland Sea) is shallow, not often below 1,600 feet and frequently much shoaler. Beaufort Sea is even deeper than the Greenland Sea.

DEPTHS

The Arctic deep sea basin probably covers a large part of the still unsounded area. The depths found during Nansen's *Fram* expedition (1893–96) range between 9,840 and 12,628 feet. Peary got 8,997 feet without bottom near the North Pole in 1909. Stefansson during his 1913–18 expedition got 4,546 feet without bottom at various points in the eastern Beaufort Sea, and Storkerson of the same expedition, farther west in the same sea, found 9,726 feet without bottom. In 1925 Amundsen-Ellsworth recorded 12,300 feet at 87°43′ N. and 10°21′ W. The deepest sounding of the polar basin, 17,843 feet was taken by Wilkins in 1927 at 77°45′ N., 175° W. Papanin sounded 14,038 feet near the North Pole in 1937. The Soviet ship *Sedov* reported in 1939 a sounding of 16,990 feet without bottom near 86°30′ N., 39° E. Other soundings in the vicinity showed depths exceeding 16,400 feet. Soviet scientists consider there is indication of a basin across the

Arctic connecting their deep soundings on the Eurasian side with that of Wilkins on the Alaska side.

SEA TEMPERATURES AND SALINITIES

It was discovered during the *Fram* expedition of 1893–1896 that the Polar Sea is covered by a layer 500 to 650 feet thick, of cold water with temperatures between 32° F. and 28.6° F.[1] and with a comparatively low salinity owing to the admixture of fresh water—river water and products of rain, melted snow, and melted sea ice freshened through aging. Then comes a layer, some 2,000 or 2,500 feet, of warmer and saltier water, with temperatures above 32°. This is Atlantic water which is carried into the Arctic basin by the tentacles of the Gulf Stream reaching northward, perhaps chiefly along the west coast of Spitsbergen. Below this there is again colder water, probably filling the whole basin to the bottom, with temperatures between 32° and 30.6° and salinity about the same as that of the warm middle layer. This cold deep layer is taken to originate in the northern part of the Norwegian Sea, north-northeast of Jan Mayen.

From Soviet press reports in advance of publication of the scientific results of the Papanin expedition, it would appear that its oceanographer, Shirshov, found within a few miles of the North Pole ocean layers which differed by temperatures and salinities about as Nansen had found them to differ some hundreds of miles to the south (in the direction of Siberia). One press statement has it that: "* * * from the surface to the depth of 200 meters, the temperature of the water is below zero [Centigrade], and from 200 to 800 meters it rises to 1.7° above zero [35° F.] This warm water is of Atlantic origin * * *. Beginning with 800 meters, and down to the very bottom, the temperature again falls gradually. The salt content in the water also depends on the depth—the highest content was found at depths of 200–800 meters."

[1] The *Sedov* reported throughout its 1937–40 drift higher air temperatures and thinner ice than encountered by the *Fram* in the same vicinity, and a drift more rapid than that of the *Fram* which they connected with the thinner ice. Some scientists consider that this may indicate a warming of the whole polar basin—which, if real, may be a short or a long cycle.

PACK ICE

Even toward the end of summer, two-thirds of the Arctic Sea is covered by drifting pack ice, formed by the freezing of surface layers during autumn, winter, and spring. The pack is in motion during all seasons of the year, floes breaking up and drifting about through the effect of wind and current, with leads of water opening and closing between the various floes. Ice to average thickness of 7 feet, and not more than 10 feet, will form through freezing in one year; ice 2 or 3 years old may be 2 or 3 feet thicker. Pressure due to currents and wind may cause piled or raftered ice to a maximum thickness of 150 or 200 feet. These extreme heapings up are never found far from land but occur chiefly at or near what is called the flaw, or floe, where the landfast shore ice meets the moving pack with resulting pressure such that ridges may pile up that have peaks 60 or 70 feet above sea level. Far from land the ridges probably do not exceed 35 or 40 feet in height.

It is not possible to calculate accurately how deep a ridge goes below sea level from how high its peak rises above it; for the ridge is pyramid or A-shaped, with its wide base submerged.

Ice fields are most level when they have been made by uniform freezing and have never been broken by pressure. In that case, if of this year's information, they have no surface inequalities except snowdrifts; if two or more seasons old, they have relief sculptured by rain, by flowing thaw water, and by sun.

PLANES CAN DESCEND UPON SEA ICE

We know from reports by the Papanin North Pole expedition that even the biggest land planes can descend with safety upon such strong, level fields as are found pretty much all over the Polar Sea in winter; for the transport pilots which delivered the Papanin group and their ten tons of supplies at the North Pole in 1937 made, between latitudes 85° N. and 90° N., about twenty different landings with heavily loaded, half loaded and light four-engined airplanes, nearly the largest then in existence, every descent followed by a successful take-off.

ICEBERGS

Icebergs have only local occurrence because, as said, there are few Arctic lands except Greenland and North-East Land that have glaciers sufficiently large and active to produce real bergs. Usually, a berg is found in a more southerly location than its point of origin, for the water movement tends to be southward.

In the heart of the Arctic Ocean icebergs are never seen. Around North-East Land, Franz Josef Land and Novaya Zemlya they are occasional. In both the East Greenland current and the Labrador current they are frequent. Melville Bay is notorious for its bergs. Of course, we are all familiar with the bergs, originating in Greenland, which in spring menace the Atlantic shipping lanes. On the Siberian coast bergs are rare—a few small ones about Northern Land.

CURRENTS

The tendency of the light surface layers of the Arctic Sea, with their low salinity, is to spread outwards, a movement which is helped by the prevailing winds and the overflow necessary from a constricted basin to which the inflow of river water is considerable, with evaporation slight. Within the polar basin the surface waters are sweeping across from Alaska and Siberia toward Spitsbergen and Greenland. Most of these waters, and the ice they carry, find their way southward into the Barents and Greenland Seas by the east Spitsbergen and east Greenland currents that flow southward along these coasts and tend to block them with streams of pack ice. Some of the polar water escapes through Smith Sound and other channels west of Greenland and feeds the Labrador current along the west of Davis Strait and the coast of Labrador. Lastly, some moves westward through the Beaufort Sea and merges again in the great transpolar drift, except a little which flows southward on the western side of Bering Strait. Thus the current off the north coast of Alaska is considered to be prevailingly westward.

But there is some evidence of a gigantic eddy north of Alaska and west of the Canadian islands, so that ice 200 or more miles north from Alaska would be moving east or north-

east; then it would curve around and move south and southwest along Borden, Prince Patrick and Banks Island; and then, as said, west along Alaska.

Through McClure Strait and Melville Sound the ice moves easterly toward the Atlantic.

Much of what we have just given on drifts is from the De Long, Nansen, Peary, and Stefansson expeditions. Recent studies of Arctic drift have been chiefly by Soviet expeditions.

The Papanin group of four was established by planes in a base camp at the North Pole in May 1937, to drift with their floe encampment and conduct scientific investigations meanwhile. The direction of the drift was as expected—towards the gap between Iceland and Greenland. By February 1938, when they were taken off their floe by icebreakers, the party had drifted to a point off the East Greenland coast between King Oscar Fjord and Scoresby Sound. The average rate of drift was more than three miles per day, which exceeded most predictions; in the vicinity of the Pole the drift was two to three miles per day, as against a drift rate which had been estimated commonly at from half a mile to a mile and a half.

The *Sedov*, Captain Constantine Badigin, repeated during 1937–1940 the drift of the *Fram* more than forty years earlier. As mentioned, their drift was more rapid than the *Fram's*; the course of their drift was also considerably more northerly.

In relation to the Arctic, there is a fundamental difference between the Atlantic and the Pacific, although they are similar in that each has a great stream of warm water flowing northward. No matter how hard it tries, the Pacific Japan Current is unable to reach the Polar Sea. It is fenced out by the chain of the Aleutian Islands and by Bering Strait, where Alaska and Siberia almost lock horns. The Strait is 56 miles across, only about double the width of the channel between Great Britain and France; and besides being narrow and shallow it has two islands in the middle. The Japan Current, therefore, instead of reaching the Alaskan Arctic with its warmth, spends its heat upon the air of the North Pacific, with only a little and practically imperceptible

amount of slightly warmed water finding its way to the north coast of Alaska.

In the Atlantic the condition is different. The waters warmed by the Gulf Stream spread northward through the wide and deep gap between Norway and Greenland splitting on Iceland with such effect that, although Arctic in name and sub-Arctic in latitude, it is temperate in weather. Nor does the Gulf Stream stop at Iceland. Its water creep north into the polar ocean and melt away the ice that otherwise would be there, so that Scotch, Norwegian, and other whalers and sealers were wont to cruise in an ordinary season more than seven hundred miles closer to the Pole on the Atlantic side than the American whalers were able to on the Pacific side.

REGION OF INACCESSIBILITY

From this it results that the center of the pack is not the North Pole, as commonly assumed, but rather that spot or region in the Polar Sea which is most difficult to reach. This approximate center has been determined by taking the farthest point attained on any meridian by all ships of which we have record. A line connecting these points bounds what is known as the area of maximum inaccessibility. Within this area the point most difficult to reach, considering attack from all sides, was determined to lie approximately at 83°50′ N. Lat., 160° W. Long. This point has been called the Pole of Inaccessibility or Ice Pole.

TIDES

In most of the Arctic, tides, properly speaking, are insignificant—ranging, for instance, from 18 inches on certain parts of the north Alaska coast down to 8 inches in Coronation Gulf.

On most parts of the north Atlantic seaboard a cake of ice that is aground during summer in shallow water has during most of the day a peculiar mushroom-like appearance; for high tide is only a matter of an hour or two, and at all other times these cakes are lying aground with the water around them considerably lower than it was at the moment of high

tide. In such places an experienced navigator can tell by glancing at a cake of ice whether it is afloat or aground. If it is afloat he can tell from the freeboard of the ice whether his ship will have plenty of water under her keel.

However, in that part of the Arctic Sea which is north of the Pacific even grounded cakes may present an appearance of being afloat; for there has been insufficient rise or fall of tide to give them undercut edges of the kind found in the east. There is practically no tide in many parts of this region—a tide of only a few inches.

But there is, at certain times, a so-called "storm tide." It seems that when a strong southwest or west wind begins to blow around and north or northeast of Bering Strait it produces a wave or swell that moves eastward and reaches the Colville delta or Herschel Island possibly 8 to 12 hours ahead of the storm itself. This rise of water that presages a strong sou'wester may sometimes amount to as much as five feet; in advance of a moderate southwest wind the rise may be a foot or two. There is a corresponding fall with or before a northeast wind. These two are, on the north coast of Alaska, the directions of the main winds.

LIFE IN THE POLAR SEA

A principle of oceanography recognized for some decades is that the amount of animal life per unit of ocean water is least at the equator and, on the average, increases toward the poles.

But it has been argued that when you come to where there is ice in the sea, or at least when you come to where the ice is thick and continuous, the principle will break down because the ice covering shuts out oxygen needed for animal life, because light will be insufficient for the biological processes of those plants upon which the animal life ultimately depends, and for a variety of other reasons. This position was until recently taken by most if not all scientists and by many explorers, as well as by laymen.

The contrary position was taken that even if the principle of *increasing* life with increasing distance from the equator did fail to hold all the way to the North Pole, still some life,

both vegetable and animal, might extend to the Pole and to every other section of the northern sea.

We consider this under the heads of logic and of experience:

Plankton, floating organisms generally, are helpless to direct their own movement and are borne along by currents. It follows that these organisms drift with the currents that sweep the polar sea. Shrimps and other larger organisms live on the smaller plankton. These, too, are carried involuntarily by the polar currents. The floating and the weakly swimming organisms in turn provide food for the strong swimmers, fish and seals: for there is no reason for assuming that fish and seals will not try to go wherever food is plentiful.

That life may be stifled by the ice covering is difficult to believe when we remember that the floes of the Polar Sea are continually breaking up, with narrow or wide leads of open water between the broken floes. The ice cakes, too, float along as well as break up, so the water that was yesterday covered by an extensive floe may be open today.

The argument that Arctic sea water may lack oxygen is further weakened when we remember that the power of water to hold oxygen in solution increases with decrease of temperature. It is known from observation that fish die from strifling through the mere warming up of the water in which they swim; it has never been more than a theoretical conclusion that they might stifle through lack of oxygen if their chill water were thickly ice-covered for long periods. That they do not so stifle we really know, for lakes in sub-Arctic and Arctic Canada and Siberia that have ice thicknesses of ten or more feet (sometimes 15 or 20 feet) remain good fishing lakes throughout the year; the fish caught in them when the thickest ice is pierced are in apparently healthy condition and usually fat, either normally or beyond average.

Many explorers (even ones who believed in the "lifelessness" of the Polar Sea) have sighted occasional seals far from land. That these explorers did not see more seals was likely enough through not expecting to find animal life in these regions and therefore not looking for it. Stefansson, who was looking for game because he fed both men and dogs

by hunting, found no diminution in seal life as he went farther from land. Papanin reported from the vicinity of the North Pole that a net raised from a depth of 3,280 feet (1,000 m.) fairly teemed with diverse molluscs, larvae, medusae, and crustacea.

In the leads at the Pole crustaceans were moving sluggishly near the surface; seals were swimming about and gulping them down.

The number of seals, from the human point of view the most reliable and valuable of Arctic food mammals, varies in different parts of the ocean. This seems to depend neither on latitude nor on distance from shore, but obviously depends on the mobility of the ice. Wherever there are strong currents, and consequent broken ice, for instance north of Alaska in Lat. 73° or 74° N., seals are abundant though it is far from shore. In areas where the ice is sluggish and consequently very thick and little broken, a scarcity of seals is to be expected. Stefansson found one such region north of Borden Island, where seals were not absent but comparatively rare.

There will be in the Arctic sea, then, certain "ice deserts." On coming to them the traveler, whose main reliance for food and fuel is upon seals, will face a problem similar to that of one who, in crossing an unknown continent in tropical or temperate regions, finds himself entering a desert produced by lack of rain. Such a traveler overland would have to depend upon his judgment. He might avoid the desert by skirting it; he might turn back, giving up his journey for the time being; or he might make a dash across, hoping that his resources would take him to the farther side of the hostile area. Just such a problem one would have to face in ice travel on coming to a region where an eddy existed and where massed ice had evidently persisted for years.

Section III

ICE: GLOSSARY

We give below a glossary of ice terms, somewhat expanded by description:

Young Ice has formed so recently that it is not strong enough for a man to walk on. We have most frequent occasion to refer to this in connection with leads.

Old Ice is from last year, or from two or three years ago. Its pressure ridges and hummocks are still fairly angular.

Paleocrystic Ice is several years old; some of it may be dozens of years old. The rains and thaws have rounded the fracture angles so that you have the general but small-scale appearance of a rolling prairie.

Shore Ice (Landfast Ice) is that ice which at one edge touches and adheres to the beach, the other edge meeting the pack. Some of the shore ice is sometimes aground, especially because the pressure of the pack has crushed it up in the fall and early winter, piling it into ridges that draw a lot of water.

The *Flaw* is where the landfast shore ice meets the moving pack.

The *Pack* is ice, of considerable extent and thickness, which is in constant motion or which is thought of as being so.

The *Shore Lead* is open water that appears when the pack moves a little away from the shore ice. If you think of the pack as still being somewhere in the offing, you speak of a shore lead even when the water is so wide that no ice can be seen from the flaw or from shore. Only in summer, or after an offshore gale so strong that you want to describe it as having produced summer-like ocean conditions, do you speak of the water outside the flaw as "the sea" or "the open sea."

A *Field* is a large coherent mass of pack ice several miles in area.

A *Floe* is smaller than a field, say acres or scores of them, instead of miles, in area.

A *Cake* is smaller than a floe, say from piano size upward. Smaller ice is called chunks, fragments.

Mush or *Brash* is what its name fairly well implies, small chunks mixed with the finely ground result of pressure between larger bodies of ice.

A *Hole* is an irregular opening in sea ice, square yards, square rods, or acres in extent.

A *Crack* is a break in ice so narrow you can step or jump over it and manage to cross fairly readily with dog teams and sledges.

A *Lane* is a crack too wide to jump across but so narrow that emergency methods frequently suffice for crossing. For instance, you get men and dogs on a cake of ice, use it for a raft and paddle across; or, by man power, you work an oblong cake crosswise in the lane so that it forms a bridge. This defines *lane* as used by sledge travelers. A sailor in a ship uses the same word to mean a passage through ice wide enough for his ship.

A *Lead* is a crack wider than a lane, from dozens of yards to several miles in width.

Pressure Ice is ice which has been broken under stress of wind or current and piled up into ridges or hummocks.

A *Hummock* is a pile of pressure ice not thought of as being particularly long.

A *Pressure Ridge* is a long hummock or a linear series of hummocks of broken ice.

Sky map.—Reflection of the terrain in clouds. Water is represented in the sky as black; snow as white; ice more or less mottled according to amount of snow covering and character of the ice itself; land as black if snowless and mottled in various ways according to snow and vegetation; pink may show in the sky from "pink snow"; yellow or brown from faded vegetation.

Ice blink; land sky; water sky.—These are portions of the sky map as described above.

Needle Ice.—Ice formed by the freezing of fresh water will in spring separate into crystals each having the length of what was the full vertical thickness of the ice when it lay horizontal. These crystals will slide past each other in such a way that ice 2 or 3 feet thick will give way under the weight of a man. The tops of the crystals are so sharp that they tear the feet of dogs and rapidly wear out the boots of men on spring journeys. (It is debated whether fresh ice that was originally salt will break into needles.)

Slush, when spoken of in winter at sea, has a special meaning which is bound up with a process not widely known, that

of the elimination of salt from brine by freezing. The process is the clearer in its stages the colder the weather.

Assume a temperature of —40° F. and an open lead. During the night ice forms so thick that next morning men and dogs can travel over it. If the intense frost continues a second day, without snowfall or drifting snow, the new ice will be fairly hard, although there may be on top of it a slight tendency to slush because it has been "steaming"—moisture has been evaporating and condensing again.

Assume, then, for the third day a quiet fall of snow, blanketing the lead and its eight or 10-inch ice as if with an eiderdown quilt. While the snowfall continues the weather will be warm (slightly below freezing). You may now reasonably suppose that the slush which you find under the snow is the result of the warm weather. However, if during the following day or two the temperature drops to around —50° (about the coldest you ever would expect at sea) and stays there, you will discover that underneath the snow the ice which covers the lead seems if anything more slushy than it was during the warm spell.

The explanation is: The freezing point of the most condensed brine is around 0° F. Your 12-inch ice has, then, on its lower side ordinary sea water at, say, 27° warmer than the freezing point of the very saltiest water. On its upper side it has brine, above that is snow and above the snow is an air temperature 50° colder than the point at which the brine freezes. This intense cold, however, does not get access to the brine nearly so effectively from above through 10 inches of comparatively nonconducting snow as the 27° temperature does from below through the 12-inch ice that is a comparatively good conductor. So the brine between the snow and the thin ice may be kept well above its freezing temperature through several days of the severest cold snap.

Fresh sea ice is produced by the continuation of the process described for the formation of slush, which results in the elimination of salt from the ice.

In the first stage, described above, when a lead freezes over, you will notice that sledges pull very hard. This is because there is a crust of salt on top of the ice, indicating the elimi-

nation process which appears to be mechanical, something like squeezing water out of a sponge. Another figure of speech is that the ice is like a honeycomb; where the ice of comparatively fresh water corresponds to the wax and the globules of concentrated brine to the honey. Throughout the winter this process continues with every cold snap, more salt being forced each time out of the ice.

When the sea ice was first formed it was salty, although not quite so salty as the water from which it was made. In April, and even in May, ice formed the previous October is still too salty for ordinary cooking uses. But in June and July, when it rains and the snow melts, with little rivulets trickling here and there over the ice, the salt crust is washed away. The saltiness of the ice now has disappeared, or at least that degree of it which is perceptible to the palate. The following year this ice is the potential source of the purest cooking or drinking water. It is fresher than any river although doubtless containing more salt than does rain or snow.

Most of the *snow on sea ice,* except that it has a little salt mixed with it, is much like snow on land. You have drifts in lees. There are no glare spots on sea ice because it is sticky; but you do have large areas sometimes where there are just a few inches of snow, and this beaten hard by the wind. Only toward spring does the snow at sea become a serious handicap to travel afoot. It then becomes *granular, mushy,* and you and your sledge sink into it as if the drifts were bins of wheat.

The *Ice Cap* was once believed to be for the Arctic, and really is for the Antarctic, an ice sheet of great thickness with its center at or near the pole and extending with fair uniformity in all directions. The ancients believed that the lands near both poles, if any, would be covered with thick ice; and that the sea, if there were a sea, would be frozen to the bottom. This frozen sea of the Arctic was at one time supposed by Mediterranean philosophers to extend well towards Scotland; later it was supposed to have its margin just north of Iceland. Such an ice cap has never existed in the Arctic; or at least not during the last several thousand years.

Inland Ice is a term used only for Greenland, where it is also used interchangeably with ice cap. The ice cap of the Antarctic and the inland ice of Greenland are considered to be snow accumulations, which through age and compression have turned to ice.

A *Glacier* is in Greenland a stream of ice flowing slowly away from the inland ice through a valley or over the top of a ridge. When this glacier reaches the sea it breaks off and forms icebergs. Outside Greenland, glaciers of the Arctic are about like those of Switzerland or of the State of Washington.

Icebergs, then, are large blocks of ice which have broken off from the edges of glaciers as they reach the sea. Some bergs are many hundreds of feet thick and several square miles in area.

An *Ice Foot* is for glaciers extending to the sea what shore ice is for sea ice.

A *Crevasse* is a crack in land ice produced by its unequal flowing motion. In sea ice we do not speak of crevasses, merely of cracks or crevices.

CHAPTER 3

CLIMATE AND WEATHER

SECTION I

GENERAL

The torrid averages warmest of the zones, but the earth's greatest heat is not found there. The Antarctic averages coldest, but does not contain the coldest spot. The north temperate zone holds the records both for extreme heat and for extreme cold. The hottest known place on earth, with a recorded 136° in the shade, is Azizia, Tripolitania, more than 600 miles north of the northern edge of the torrid zone. In the New World the hottest place is Death Valley, California, about 900 miles north of the Tropic of Cancer, with a recorded 134°. The coldest known spot is Oimekon, Siberia, more than 200 miles south of the Arctic Circle. Both hottest and coldest places are on low ground.

It is now believed that temperatures colder than those on the earth are not reachable above the earth. For instance, the U. S. Army-National Geographic balloon ascent over South Dakota by Stevens and Anderson found its coldest temperature in the twelfth mile altitude, 81° below zero. This is thirteen ° less cold than the Verkhoyansk observation taken at 328 feet above sea level. During the rise from the twelfth to the thirteenth mile the temperatures above South Dakota grew less cold, −68° at the highest altitude reached.

The zone of the most intense cold above the earth is considered to be farthest from the earth at the poles, nearest at the equator.

There is a belief, too, that a far more intense cold may be recorded on high lands that are extensive—on high plateaus—than on mountain peaks of the same latitude. "Ground" level temperatures from −80° to −85° have been observed on the Inland Ice of Greenland at 9,000 and 10,000 feet 200 and 300 miles from the sea. It is thus much colder on high Arctic plateaus than at the same land in the free air, and somewhat colder than at any free air level; but not as cold, apparently, as in certain low, forested areas of the North Temperate Zone.

The lowest mean temperatures of the northern half of the earth are doubtless those of the Inland Ice, probably around 70° or 80° N. Lat. and near or just east of the median line of Greenland. So that although Oimekon, in the temperate zone, is the Pole of Cold Intensity, some spot in Greenland is the Pole of Mean Cold.

Coasts do not run to extremes like interiors. Point Barrow, Alaska, for instance, goes from −56° to 76°, a range of 132°. The range on Arctic islands, other than practically continental Greenland, is on their coasts similar to that of Point Barrow; but the range is greater in their interiors, if they are large. On the pack ice the range is least of all. At the North Pole it probably runs from about −55° to 45°, a spread of about 100°.

The northern polar zone, with which this work mainly deals, has great intensities of heat and cold, though it does not quite reach extremes. The hottest record, under Weather Bureau conditions, is at Fort Yukon, Alaska, a few miles north of the Arctic Circle—100° in the shade. The coldest is Verkhoyansk, Siberia, about 50 miles north of the Arctic Circle—94° below zero.[2]

[2] The lowest temperature so far actually recorded under weather bureau conditions anywhere in the world is at Verkhoyansk; but during the first 10 years of the recently begun regular observations at Oimekon that place averaged considerably lower. It is therefore generally agreed that Oimekon, 300 miles southeast of Verkhoyansk and 200 miles south of the Arctic Circle, will establish some time a record lower than Verkhoyansk. (It is believed by

Fort Yukon may have the greatest individual temperature range of the American Arctic, from 100° to —71°, or 171°. The probable American Arctic range will be approximated by using Good Hope, Canada, as if it were an Arctic post though it is perhaps 25 miles south of the Circle; its minimum is lower than that of any known Alaskan or Canadian Arctic spot, —79°. The gap from that figure to Fort Yukon's 100° F. is 179°, the (as said) probable American Arctic range.

The Old World Arctic individual range is from 96° to —94° at Verkhoyansk, 190°. The temperature range of the north temperate zone is about 225°. The United States comes in between with a range of around 200° (from Riverside, Wyoming, —66°, to Death Valley, California, 134°).

SECTION II

TEMPERATURES

a. Summer

As said, the maximum temperatures recorded within the Arctic Circle under weather bureau precautions and conditions is 100° in the shade. While this record has been made only once, and in only one place, temperatures of 95° have been recorded at numerous times in many places. Heat of 85° to 90° may be expected most anywhere, no matter how far north, if the following conditions can be met: land low, snowclad mountains remote, distance from the sea more than 100 miles.

The crucial thing for determining Arctic summer temperature is local delivery of heat direct from the sun, or rather of light—not the arrival of heat from a distance through currents of air or water. In fact, the extreme Arctic summer temperatures have been recorded, nearly or quite all of them, in places notably removed from warm ocean current influence.

At the top of the earth's atmosphere the sun delivers on June 22 a little more heat each 24 hours at the North Pole than at the equator; the amount computed to reach sea level

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some that —90° should be accepted as a "corrected" reading for Verkhoyansk.)

is at the Pole about 3 percent or 4 percent less than at the equator.

The degree to which light is converted into heat depends mainly on the color of the surface struck by the rays. On most Arctic lands most of them strike a dark surface; for winter snowfall is light and the snow tends to be swept by wind into gullies or piled in the lee of hills. Grass, which is yellowish or brown, sticks up through the snow; there is sand and dust on the snow; rocks project in some places. When these and similar things are taken together with the large areas that are practically bare, you have, even in early spring, much opportunity for the sun's rays to be converted into heat, instead of being reflected as light.

PERCENTAGES OF SNOWFREE LAND

The little snow there is disappears rapidly from 80 percent to 90 percent of the land. This land is then a vast radiator to melt snowdrifts and to create hot weather. Accordingly, all snow, except a few banks in gullies, will disappear every summer from all land in the Arctic, except from mountains and from lowlands so near mountains that glaciers can slide that far before being melted. Roughly this means that in late August 80 percent of all land north of the Arctic Circle is free of snow. Most of the snowclad, 20 percent, is in Greenland. That country, as said, because of a combination of mountains and precipitation, is estimated to be from 80 percent permanently snow-covered; however, one of the largest areas of ice-free land is found at the north tip—Peary Land, which is 1,500 miles north of the relatively ice-covered south tip of Greenland.

In midsummer, temperature differences between night and day are in the Arctic small compared with those of tropics or temperate zone. For the sun, though not so efficient when low, is nevertheless shining at midnight and delivering some heat.

High northern temperatures, found, as said, only on low lands far from the sea, are likely to be more distressing to people than the same temperatures farther south, for three chief reasons:

1. In those parts of the Arctic where temperatures run high, all the land is a swamp. The heat is therefore very humid.
2. The sun does not set and you do not have at night that relief from its heat to which you are accustomed nearer the equator.
3. Mosquitoes, sandflies, and other biting pests compel you to dress heavily in the Arctic, no matter what the heat, as against your ability farther south to dress lightly or even to go partly naked.

The possible extremes of Arctic heat, and the possible attendant discomfort, were so graphically described by Lieutenant Frederick Schwatka, United States Army, from his Yukon River expedition of 1883, that we cannot do better than quote him. He was traversing that short stretch of the river which, in the vicinity of Fort Yukon, lies within the Arctic Circle. It has been found since that this district has more intense summer heat than any temperate zone portion of Alaska. Lieutenant Schwatka says that July 29, 1883, "* * * was an exceedingly hot, blistering day on the river and almost unbearable on the raft * * *. Here, within the limited part of the Yukon River in and near the arctic zone, our greatest discomforts were the blistering heat and dense swarms of gnats and mosquitoes that met us at every turn."

SUMMER TEMPERATURES AT SEA

Sverdrup, depending mainly upon the observations taken by the *Fram* and *Maud* expeditions, says that as spring advances the temperature of the polar sea area rises until 0° C. (32° F.) has been reached and the melting of the snow cover and the top layer of the ice commences. During the melting the temperature on the surface remains at freezing, and that of the air just above can never deviate far from this norm. Therefore temperature fluctuations are slight during the summer months.

This does not mean, however, that you might not feel uncomfortably warm if dressed in an ordinary dark business suit and walking around on the sea ice. Melting is rapid wherever the sun can find a dark spot.

Elsewhere we have referred to the experience of travelers on the northern pack with the disagreeable amount of melting that occurs during summer. There have been climatologists, however, who maintained that north of 85° there would be negligible melting of the snow, or of the ice, since no land would be anywhere near to create local heat. This failed of confirmation by the Papanin expedition which started its drift from about 90° North in late May, 1937, and was moving south (toward the Atlantic) through latitudes 89° and 88° during June. For that month Fedorov says: "Summer brought us an abundance of water. All the surface snow melted, as did likewise the top layer of ice. Large puddles of fresh water covered the surface of the ice floe * * *"

On June 11, while the party was still north of 88° and apparently during the same heat wave which produced the melting described above, Papanin, the leader of the party, noted in his diary: "At midnight the weather became calm. On the sky not a single small cloud. The sun warmed our black tent to 24° [75.2° F.]. There's the North Pole for you!"

Even allowing for the attraction which the black tent would have for the sun's rays, it is apparent that in summer there is a wide spread between the almost constant freezing temperature of the ice surface and the temperature of the air 2 or 3 feet above it.

This becomes the more evident when we read in press dispatches such things as what Captain Badigin said about temperatures on the *Sedov* at 85°32′ N. Lat., 61°50′ E. Long. He reported on July 24, 1939: "Summer weather has set in after the rains. The thermometer now registers 25° to 27° C. [77° to 80.6° F.], and the hummocky ice, once so grim, is becoming transformed into wretched mounds of melting snow. Numerous little lakes, more than 300 meters in length and about half a meter deep, have formed on the surrounding ice. Taking advantage of the warm weather and the appearance of lakes, the crew has gone in for a new form of recreation, cruising around in their canoes."

There appears no doubt that Captain Badigin is here wanting to tell us about what seemed great warmth in view of his situation out on the polar sea. However, there is probably

some mistake, or the necessity for a qualification, about the 77° and 80.6° temperatures. Surely the thermometer which registered that high must have been in the direct rays of the sun (in view of how near the ice was to give a countervailing chill).

Or did the newspapers lose a decimal point when setting up the type for this dispatch—were the readings perhaps 2.5° C. and 2.7° C.? That would be 36.5° F. and 36.9° F. In that case the temperature was probably taken on the regular weather bureau scheme of having a thermometer shelter about four feet above the ice where the instruments were protected from direct "radiation" of the ice from below but where all four sides of the cage were open to the winds, though not to the sun, in a manner that permitted free circulation around the thermometer of air that had been chilled by the ice in the vicinity.

When thermometers register 36° or 37° F. under the conditions described you would be uncomfortably hot while reading them if you were in the direct rays of the sun while doing so and were clad in an ordinary business suit of dark color. Under those conditions, too, you would have on top the sea ice towards the end of July lakes of the size and depth which Badigin describes.

GENERALIZATION ON HEAT AND COLD

What you do with extremes of heat and cold differs fundamentally. In the main you endure the heat; in the main you protect yourself from the cold.

Our discussion of warm weather and extreme heat needs little development. The users of this Manual are experienced in dealing with heat. Besides, there is less use explaining how to endure what you have to endure than how to avoid what you can avoid. The section on warm weather and its technique is therefore brief, while that on winter, its conditions, and methods will occupy the main part of our book.

b. Winter

As said, the most intense cold yet reliably recorded on the earth's surface is −90° or −94° F. (about 125° below freez-

ing). Temperatures approaching this are likeliest where a lowland far from the sea is surrounded by mountains—that, for instance, is the condition at the coldest spot in the United States, Riverside, near the Montana-Wyoming line, which is the same distance north of the equator as Milan, Italy, and Portland, Oregon. The Arctic's coldest place, Verkhoyansk, is similarly on lowland surrounded by mountains, and that is likewise true of the world's cold pole, Oimekon. (See discussion *ante.*) All these record-holding localities have it in common, too, that they are remote from the sea and its influences. All have hot summers and are forested.

SEACOAST MINIMA

There is probably no place on any seacoast in the Arctic which can show as low a minimum as Riverside, Wyoming. For instance, the lowest yet recorded by the Weather Bureau at Point Barrow, Alaska, over 300 miles north of the Arctic Circle, is $-56°$. The lowest on the north coast of Canada is $-52°$ at Herschel Island, 200 miles north of the Arctic Circle.

That even narrow seas in the midst of a great deal of land have a marked effect on the temperature appears to be shown by such experiences in the Smith Sound region of Greenland as those of Commander Donald MacMillan and Dr. Noel Humphreys, MacMillan reported $-37°$ as the lowest of the winter 1934–35. These records were taken some 500 miles farther north than the north tip of Alaska and some 800 miles north of the Arctic Circle. There is no known warm sea current nearer than 800 or 900 miles east, on the other side of 9,000-foot-high Greenland; so it is really ice water (water around 30° F.) that warms up the Smith Sound region—and most of it is water frozen over in midwinter, so there must be considerable radiation through sea ice.

At sea, no matter how far north you are, the temperatures are likely to be those of the coasts; so that we can safely assume a weather bureau thermometer at standard elevation on an ice floe at the mathematical north pole would in a hundred years fail, by something like five or ten de-

grees, to record a temperature as low as the minimum for Wyoming. The coldest Nansen ever recorded, while drifting three successive winters at distances of 500 to 1,000 miles north of the Circle, was −54°.

VARIATION IN COLD WITH ALTITUDE

That valleys are colder than hills during the chilliest parts of a northern winter is, of course, because cold air is heavier than warm, thus flowing down slopes into valleys and pockets. The like is why airplanes which take off from low ground in intensely cold weather usually find themselves flying at considerably warmer temperatures even a few hundred feet up, and much warmer at half a mile up.

The change between hill and valley is striking when you travel afoot at temperatures of −50° or lower. On climbing a hill you feel as if you were going upstairs into a warm room; when you descend a slope it is like going down into a chilly cellar. The same is, of course, the reason why the midsummer frosts which kill grain in the temperate zone take their quickest and heaviest toll in low places.

We have pointed out, *ante*, that this reasoning does not apply to extensive plateaus.

c. Physical Effects of Cold

In later chapters we discuss the effects of cold on instruments, tools, and other paraphernalia, with suggestions for dealing with the problems created. Here we consider some of the effects of cold on the natural surroundings.

Perhaps the most conspicuous effect of cold on air is to dry it. A demonstration under practically laboratory conditions occurs whenever you open in cold weather a European-type door that leads out from a heated room. At temperatures like −50° outside and 70° inside, and even with the air of the house fairly dry (as when no cooking is going on), you observe a cloud of steam rushing in along the floor. This thins as you go upward and somewhere around the middle of the door it ceases to be noticeable to the occupants of the room. Persons outside get the reverse effect. They see a cloud of steam rushing out from the upper half of the door, densest at the

top. The air is being dried in both cases. Along the floor the damp air of the house is chilled, producing moisture that starts settling toward the floor and which, if the conditions are just right, will strike the floor as hoar frost. The air escaping from the upper half of the door is dried when it gets out, the vapor again appearing first as a fog and later turning to silver particles[3] that flutter to the ground, once more assuming the conditions for observation are just right.

Air at −50° is no doubt considerably drier than any that can be found at 100° over a tropical desert. However, the drying of a wet piece of cloth would be retarded several hundred, if not several thousand, percent by the 150° drop, through the moisture turning almost instantly to ice. It will take several days for a wet cotton handkershief to dry in still air at −50°.

Probably the drying of the air is the chief, though not sole, reason for several of the astmospheric phenomena described just hereafter.

At temperatures in the −30° to −60° range there are various extreme phenomena of sight and sound. Your hand, though apparently dry when you pull it from a mitten, will steam at −60° almost as would at room temperature a cloth soaked in boiling water. Mosture from a dry face or dry hands will cloud spectacles, field glasses, sextants. The moist eye produces more pronounced clouding and frosting of instruments; the breath is still worse, of course. We treat this subject in detail elsewhere but mention here that clouding of surfaces can be avoided or lessened in various common-sense ways.

For the same reason bodies of ice-cold water at low temperatures will steam as if they were boiling. Clouds will rise from flooded rivers, or from leads at sea, that resemble the smoke of a forest fire. Animals and power vehicles leave "fog tails" or "fog trails" behind. At −60° or colder there is a trail in the air behind running caribou or behind a speeding airplane, as if a smoke screen were being laid. An extreme

[3] "First as fog and later turning to silver particles" is, perhaps, questionable. It has been maintained that there is direct passage from gas to solid at very low temperatures. It has also been claimed, however, that liquid particles of extremely small size may long persist in very cold, still air. We do not attempt deciding these points.

report is that a reindeer, probably as dry as it could normally be, was invisible from its own steam at 10 feet. This report is from near the Siberian pole of cold, presumably at a temperature lower than $-80°$.

A reindeer or a horse can be invisible through its own fog, of course, only from one side—the side toward which its moisture is slowly drifting.

VISIBILITY AT LOW TEMPERATURES

Visibility is the greater the colder the air, providing it is not interfered with by condensing moisture. At $-50°$ you can see comparatively small objects two or three times as far away as at 50°, and remote things, such as mountains, acquire neither the purplish appearance which we associate with distance nor the blurred outlines, so that judging distance is not merely impossible to a man unused to cold weather but even to one who is used to it. For instance, after seven winters of Arctic experience Stefansson mistook for a small hill a mile away what proved to be a mountain 20 miles away. He walked toward it for several hours and it constantly seemed about as far from him as when he started, until perhaps within the last hour or so.

Flyers who took part in the International Polar Year expeditions of 1933 have said that they could see as clearly at 50 miles in the Arctic as they could at 10 miles in the Dutch East Indies.

NOISES AT LOW TEMPERATURES

The powers of hearing, or rather facilities for it, are increased more than those of sight. Under ideal conditions, with a temperature of $-60°$ to $-80°$, you can overhear an ordinary conversation at distances from half a mile to a mile. You can hear a man stamping his feet on the ground at 2 miles, and at 10 to 12 miles you can hear the barking of dogs or the chopping of wood with an axe.

d. Special Aviation Problems

The icing of wings of airplanes in very cold weather may be due in part at least to atmospheric content as well as to

air temperature, since some flyers have never experienced it at all while others have been brought down by it. There is seldom icing at 28° to 32°, though it has been reported within this temperature range both from Alaska and the States. There is probably little or none at temperatures above 35°. Icing conditions of the rime type have been reported from temperatures as low as —40°. According to American and Canadian Arctic testimony, the worst icing range there is between 15° and 25°.

FROST ON WINGS, ETC.

A condition which, in Alaska, may trouble in several kinds of weather is the deposit of frost or rime (as opposed to ice) on the wings, changing their contour. This frost is frequently seen on planes that stand overnight, even in perfectly clear weather, and it is standard Alaska practice to sweep wings, propellers, and other parts clean of frost before taking off in the morning. If the plane is left standing for any length of time during the day, frost is likely to gather again, necessitating further sweeping. In extreme and infrequent cases frost in quantity enough to bother has been known to collect while the plane was taxiing down the runway for a take-off.

As said, this frost accumulation may occur at almost any time when temperatures are low, no matter how clear the air may be—it is, in fact, said to be of more frequent occurrence on clear days than on days of light fog.

Temperature inversions occur in winter frequently. There are more of them and they are more pronounced as the cold becomes more intense. Apart from being slightly guilty of reasoning in a circle, we may say that temperature inversions are greatest in coldest weather and that the most intense cold at ground levels is the result of temperature inversion.

As said, temperature inversions depend on cold air being heavier than warm. Air dries as it chills and to that extent it must be lightened on chilling, since moisture is heavy; but evidently the increase in weight per cubic volume due to chill is greater than the decrease in weight due to elimination of

moisture. You have, then, usually in temperature inversion air near the ground which is both extremely heavy and extremely dry.

These inversions are most pronounced on the calmest days. When there is a wind, the air is churned up; and if the wind is at all strong the inversion disappears completely for all practical purposes. The greatest inversions undoubtedly occur in those topographic configurations which produce the greatest cold. They occur, therefore, oftenest at considerable distances from the sea and are most pronounced where a low land is surrounded by high mountains. There is said to be an ideal configuration of this sort at the pole of cold, Oimekon, Siberia.

Examples of temperature inversions:

Alaska, Circle Hot Springs, ground −49° F.; 2,000 feet up, 30° F.

Canada, northeastern coast, ground −49° F.; 1,000 feet up, −7.6° F.

Canada, Mackenzie district, ground −60° F.; 1,500 feet up, −25° F.

Temperature inversions become noticeable in a rise of 50 feet or less. There is likely to be no pronounced temperature difference between the 1,000- and 1,500-foot levels and 2,000 to 2,500 feet. That there may be no appreciable difference for 6,000 feet is the experience of W. E. Gilbert, who was trying to get out of a freak cold condition. The ground temperature at Fort Norman, lower Mackenzie River, in January 1934, was −72°. In the air it grew warmer up to 1,500 feet, where it was −47°. The air remained at about −47° from 1,500 to 6,000 feet.

Further special aviation problems are discussed below under Fogs.

SECTION III

WINDS AND GALES

Nansen said that it was an outstanding conclusion from his studies that the Arctic, taken as a whole, is less stormy than perhaps any other region of equal size in the world. He gives maximum wind velocity for 3 years at sea, 100

miles and more from land, as 50 m. p. h. De Long, after drifting far from land for more than a year in the *Jeannette* north of eastern Siberia, said it was strange how seldom the wind blows and how gently it blows when it does. Stefansson considers he has never seen more than a 50-mile wind when more than 50 miles from shore.

However, these are winds measured only 10 or 20 feet above ice-surface level at sea. The observations of Harald U. Sverdrup with balloons would indicate somewhat stronger winds aloft.

CONFLICTING VIEWS

Statements are frequent in print that howling gales are numerous, or even that gales blow steadily for weeks on end. Sometimes these statements generalize that "the Arctic" is a region of gales. The words "Arctic storm," "Arctic blizzard" convey terrifying impressions to most.

What such travelers have meant when they said that the Arctic was stormy can be interpreted that they observed strong gales where they happened to be and did not realize they were local.

Stefansson considers that a reconciliation of the statements may be found by such things as comparing his experience far at sea on sledge journeys with his experience at Langton Bay (between Cape Bathurst and Cape Parry).

On a typical occasion he was traveling from inland north toward Langton Bay. When he was still 8 or 10 miles from the coast, a perfect calm changed to gentle breezes at his back. The wind continued increasing as he approached the escarpment of the 1,500- to 2,000-foot plateau which is here 3 miles back from the sea. On beginning the descent, the gale was terrific. The land was bare except that here and there patches of snow had been pounded till they were like glare ice. Pieces of slate were torn from the cliffs as he descended a ravine and these went spinning down ahead of him. As he traversed the mile of flat land between the foot of the escarpment and the base camp of his expedition on the Langton Bay sandspit, the cartwheels of slate kept overtaking and passing him. Going north beyond the camp, along the land

which runs toward Cape Parry, he found the wind steadily decreasing. In 3 or 4 miles it was a gentle breeze again. Looking back he could not see the cliffs for snowdrift, although the weather was otherwise clear.

SEA ICE ROCK STREWN BY LOCAL GALES

So much slate was torn from the cliffs during the winter that in the spring when the snow began to melt, sledge travelers had to keep well out on the sea ice, a mile or two from shore, along stretches between Horton River and Langton Bay—the whole surface of the ice near land was black with a layer of slate.

Through several years spent in the vicinity of Langton Bay, and through interviewing natives, Stefansson found that the gales of the type described begin to blow soon after the freeze-up, or as soon as there is a pronounced difference in temperature between land and sea, the land being colder. Apparently there are currents of light, warm air rising over the water and the cold heavy air pours like an invisible Niagara off the plateau escarpment to fill the space being vacated by the rising warm currents.

This local wind keeps ice from forming near the beach; any crust that forms being broken and carried out to sea. The winds continue increasing toward midwinter; for the temperature discrepancy between sea and land keeps growing more pronounced. But some day this local offshore gale will be interrupted by a storm of considerable area and strength blowing from the northwest. This brings the pack into Franklin Bay. If then cold weather follows, everything freezes solid.

The warm water of the bay is now insulated from the air by so much ice and snow that the conspicuous difference of temperature between the plateau and the sea margin no longer holds. The violent locally generated gales are over for the year, though there may continue some of the same processes on a milder scale.

These Langton Bay gales are narrowly local. Broader, but still in a sense local, are the gales from the Mackenzie mouth

westward along the coast. They are about as bad as the worst blizzards of North Dakota but are more frequent. Storms deserving the name of blizzard probably occur on an average two or three times a month at Herschel Island, frequently lasting several days each. Three days is not an uncommon duration.

LOCAL STORM AREAS

Our general statement, then, follows Nansen, that the Arctic as a whole is not a windy place. We qualify by saying that there are regions of intense local storms, usually where high land faces the open sea. The most conspicuous case of that relation is Greenland. While the center of the Greenlandic inland ice is probably on the average quiet, the coasts are probably the windiest regions of the northern hemisphere. However, it is found that gale violence does not usually extend more than 10 or 15 miles out to seaward.

With the exceptions well in mind, a general understanding of world weather furnishes a grasp of the situation in the Arctic. From a map showing contours, and with the knowledge of the seas in the vicinities of land, you can, in a general way, forecast Arctic weather as to storminess—you can tell when you are about to enter a region where local gales are to be expected.

There are a score of practical applications, one of them illustrated by the experience of Storkerson of the third Stefansson expedition. He once camped at a certain place for a week in a continuous and terrific winter gale and finally returned from a surveying journey only to realize, years later, that if he had advanced perhaps half a dozen miles he would have been in good weather. This slip prevented the expedition from completing the mapping of Victoria Island.

Another sample practical dodge is to avoid a gale by getting right up close to the cliff that produces the wind. If the cliff is high and fairly precipitous you will be in a position analogous to going behind the waterfall at Niagara. Niagara water cascades out only a few feet or yards, however; a Greenland gale, it is said, may not strike the lowland for as much as 2 or 3 miles beyond the escarpment over which it is cascading.

SECTION IV

PRECIPITATION

It is difficult to measure Arctic snowfall because the snow is usually dry and fluffy and is driven about a good deal by even the lightest winds. There is no doubt, however, that on the average Arctic precipitation is very light. It is estimated that, if the snow of winter be added to the rain of summer, the result would be about 8 inches of water, certainly not more than 10, on most parts of the Arctic lowlands of Canada and Alaska. The Siberian lowlands may be even drier. We have, therefore, the apparent paradox that the average snowfall of the Arctic is much less than that of Scotland or Iowa. A further seeming paradox is that, although some parts of the Arctic have an annual precipitation so light that it would bring about desert conditions in any state of the union, the ground is nevertheless a swamp in practically any part of the Arctic that is not rocky.

The reasons why these are no more than seeming paradoxes are chiefly two—that evaporation in the Arctic is very slow and that in most parts there is no underground drainage. Both these subjects are treated elsewhere in this Manual.

FACTORS CAUSING PRECIPITATION

Whether moisture from the atmosphere is precipitated depends mainly on two factors: on how much moisture there is in the air and on what the factors are that bring the air to the condensation point.

In a country like Iceland one sees frequent and vivid examples of the role played by mountains. In few countries is there a more abrupt rise from the sea, but still there are often low coastal stretches. The air moving in from the sea across these will be perfectly translucent; when it strikes the mountains you see that the precipitation gradient is related to the slope of the mountain, for you note slight evidence of precipitation low down on the slopes, more and more as your eye travels upward, till the higher part of the mountain is concealed from you by a cloud that soon starts delivering rain or snow.

No doubt it is for a reason of this sort that the winds are able to deposit on Greenland snow enough to maintain the Inland Ice. If Greenland were a low country, many of these winds would no doubt sweep all the way across it without producing rain or snow. In this we have a large part of the explanation of why Peary Land in the north of Greenland is mainly snow-free toward the end of each summer. The same reasoning explains why most of the islands north of Canada have no glaciers, or negligible ones, and why the glaciers we do find are in the easterly part of the archipelago. They do not have flowing over them air that starts out with a higher degree of moisture but they do have mountains that are good at capturing moisture.

Most of the Arctic has the heaviest precipitation in the spring. On the north coast of Alaska from which, as said, it is so difficult to get instrumental verification, we have, nevertheless, a consensus among observers that more snow falls during April, May, and the first part of June, than during the remaining 9½ months. It rains a good deal in summer, so that if the rain were snow it is possible that the summer precipitation would impress observers as much as does that of the spring. Fall is inclined to be cloudy, and snowfalls are frequent but average light in comparison with spring. From November to March, inclusive, the precipitation is light.

In their frequency and denseness fogs run somewhat like the snowfalls. Both are heavy in spring. The summer rains may approximate in water content the spring snows, but the fogs of summer are markedly lighter and fewer than those of spring. In autumn both fogs and snowfalls are frequent, but neither of them as heavy as in spring. In winter, fogs as well as snows are few, the fogs, however, relatively even fewer than the snows.

These general remarks on fog must not be understood to contradict what is said elsewhere specifically about *local* fogs.

The above on seasonal variation of precipitation, based directly on the north coast of Alaska, is broadly applicable to the Arctic coasts of America and Eurasia and, with modification indicated hereafter, to the islands. A separate statement is required for the interior of the Polar Sea. Here we depend

mainly on Nansen (1893–96); for the only studies which cover the field, and perhaps even more adequately, are those of the *Sedov* (1937–40), which have not yet been published.

Nansen, whose observations for 3 years were in the main at least 500 miles north from the north shores of the Eurasian mainland, found that the variation of snow precipitation by seasons was similar to what we have described for Alaska, with a chief difference in that the winter season, the one from the decrease of the autumn snows to the increase of the spring snows, was somewhat longer than on the Alaska coast. The heaviness of the spring snows, in comparison with the other seasons, is perhaps less marked near the center of the pack than it is near the pack margins and on the mainland shores. The decrease of snow in winter is, on the other hand, more marked in the pack than on the coasts.

Most striking of the differences between the central pack and the Arctic coasts is the decrease in winter fogs. We cannot say for the coasts more than that fogs are few in winter. Nansen says for the pack outright that there are no fogs through the 4 months December–March, inclusive. This does not mean, of course, that the sky is never overcast, for it sometimes is; although that condition is also more rare than on the coasts.

SECTION V

FOG

a. General

Generally speaking, the central area of the polar sea, where the floating ice is heavy, is considered to be not very foggy—its interior less foggy than its margins and the margins less foggy than the region of looser ice farther south. No doubt there are least fogs in midwinter (the period from December to March or April); Nansen considered you might fairly say that there is no fog near the center of the Arctic pack from December to March, inclusive. In spring fogs apparently occur occasionally; the summer months, particularly July, are worst, and then the fogs become fewer as autumn advances.

COASTAL FOGS

Arctic lands are, generally, warmer than the seas in summer, colder than the seas in winter. Accordingly, it is in summer a warm land wind which produces a fog at sea; in winter it is a cold land wind that produces it. In reverse case, during summer it is the comparative chill of the sea wind that makes fog on the land, while during winter it is its comparative warmth.

A vacillation of the winds, therefore, produces a fog belt more or less parallel to the shore, covering a strip of land and a strip of bordering ocean. Where a peninsula juts out into the sea the entire peninsula, unless very wide, will have the disagreeable coastal climate, though not as pronounced along the median line of a widish peninsula as along its shores. Similarly, a bay of cold water is often foggy in summer, for some land wind will be blowing across it at nearly any time. The shore to the lee of the bay will be foggy.

The rule, to which there are exceptions, is that coastal fogs are fewest in winter, the longest season of the year; next in order of fewness is midsummer; then comes autumn; their greatest frequency is in spring.

It would seem that in midwinter, when the land is coldest, a land wind would most quickly produce a fog at sea. This would be the case if the sea were unfrozen, and is true whenever a gale or other factor has taken away the ice or prevented its forming. But ordinarily the sea near land is covered with such thick ice in winter that a land wind does not produce much of a sea fog.

Similarly the ice covering of the sea prevents a sea wind from producing spectacular land fogs in winter.

We turn now from winter to spring, the season foggiest upon Arctic coasts. The sea is then likely to be very much colder than the land. There have been during winter temperatures as low as —50° at sea and some of this vastly below-freezing chill must have been stored in the ice, to be liberated gradually. On shore the sun that is melting the snow is already fairly high and it is shining for a good deal more

than half of the 24-hour period. It has begun its thawing by striking dark objects. The heat that radiates from these initial dark areas soon melts the neighboring snow and creates more dark areas which in their turn become radiators.

It may be thought that the chill to which the sea has been exposed in winter, and some of which has been stored, will have been playing with even greater forces upon the land, with storage of chill resulting there also. This has only slight practical truth; for there are two conditions which make chill storage by the land negligible and make ineffective what there is of it.

To begin with, the land is during winter partly snow-covered. This blanket of insulation protects whatever lies beneath it from a good deal of the effect of the winter chill. The cold that does penetrate the snow is then met by a second insulator, not so good as snow but a whole lot better than ice—frozen earth in some places, rock in others. Accordingly, the penetration of winter cold is not very deep. It has been considered that it will not go through more than 9 or at most 12 feet of earth.

However, the ground is frozen for a depth which in places has been found to exceed 300 feet. There is, then, a vast amount of chill in storage. Accordingly, the second factor is the important one, for it prevents the escape of chill that has been stored.

When the land begins to steam in spring under the heat of the sun its very steaming has a cooling effect upon the ground itself, somewhat as perspiration and evaporation from the human skin cools the body, so that thaw is thereby hindered from deep penetration. When the thaw has made its way down several inches the thawed layer becomes and remains an insulator which prevents any such effective upward escape of chill as would materially change the weather.

SIX-FOOT TEMPERATURE RANGE AT FORT YUKON

For illustration, take conditions observed through a vertical height of less than 6 feet in the garden of the Hudson Stuck Memorial Hospital at Fort Yukon. In July 1918, the

shelter holding the weather bureau thermometer was standing in the potato patch about 4 feet above the ground. Within this shelter, of wood painted white to evade heating by the sun, with sides of slats to admit the wind freely, but with a floor of boards to shut out direct radiation upward from the black soil of the garden—under these conditions the thermometer registered on various days varying temperatures between 80° and 95°. A few inches below the surface of the ground were potatoes growing towards maturity which was to be only a week or two later than that of similar potatoes in Vermont. Less than a foot below the growing plants was the upper limit of "eternally" frozen soil.

We had, then, in that garden a heat range from the freezing point a foot below the potatoes to 95° 5 feet above them. Twenty or thirty feet farther down there was, no doubt, a temperature which is ordinary for those depths in the Arctic, around 10° F.

The ground, then, does not release much of its stored chill because its top layers imprison the chill; sea ice releases its chill readily, some of it to the ocean waters beneath, some to the air. Sea water releases its stored chill readily both through being a good conductor and through being constantly churned up by winds and currents so that colder layers farther down are brought to the surface.

The amount of warmth generated ashore during, say, 20 hours of continuous May sunshine is tremendous; and this during the period when the sea ice is still at least somewhat below even the freezing point of ordinary sea water, which is 3° or 4° below the freezing point of our Fahrenheit thermometer scale (around 27° or 29°). Naturally, then, the sea winds will produce land fog. Similarly, land winds in spring create sea fogs.

When the temperature is, say, 50° or 60° in the shade, the fog caused by a sea wind would be densest somewhere between 5 and 10 miles inward from the shore, while its farthest extension inland would not be much beyond 20 miles. Most of these summer fogs are low, whether on land near the sea or at sea near the land. For instance, on the sea off the north coast of Alaska, whaling captains often could see each other,

crow's-nest to crow's-nest, when sailors on deck could not see from ship to ship. Inexperienced aviators might remain grounded for days under such conditions, not suspecting that moderate hills, and even a hundred-foot mast, would show above the fog.

The Arctic islands are, of course, subject to the same conditions that produce mainland coastal fogs—with variations according to the size of the island and in some cases in relation to other circumstances.

In summer even small islands like Lougheed (30 miles by 10 miles) generate enough heat for the creation of local fogs upon them; but hardly any fog of consequence at sea is produced by so small a radiant body of land.

An island like Banks (medium-sized for the Arctic—150 miles wide and nearly twice that long), gets away from being wholly oceanic and coastal. Western local sea fogs rolling inland have their summer limit commonly around 20 miles from the beach, and similarly for the south limit from the north coast and the north limit from the south coast, so that nearly half the land surface will be reasonably fogless during the summer. Much of central Victoria, example of a large island, was reported by Eskimos to Stefansson as comparatively fog-free—probably a true report, since it fits with theory verified elsewhere.

A case worth noting for its application generally is that the 10- to 20-mile Prince of Wales Strait, between Victoria and Banks, is not wide enough to chill east winds enough so they can generate a pronounced fog when they move west into Banks. This wind really comes from Victoria Island, where it has been warmed, and produces fog on the strait (as would a westerly or Banks Island wind); but this fog is not carried very far inland usually—and, as said, little or no true land fog is generated.

BELTS AND TIMES OF POOR SPRING VISIBILITY

The Canadian Archipelago has, at such lines as the one which joins the seaward promontories of Borden and Meighen Islands, spring and early summer belts of almost continuously bad visibility—the fogs and snows of spring merge into the fogs and snows of autumn, with not a very

appreciable slacking between. But you don't have to go far southeastward into the Archipelago to note an amelioration in midsummer.

The above-mentioned line drawn from Meighen Island southwest, touching western Borden and Prince Patrick, runs through a belt which has probably the worst visibility in the Arctic between May and November, for the descriptions of the only travelers who have been there, McClintock, Mecham, Isachsen, and Stefansson, agree in portraying worse conditions in this respect than have been reported by travelers from anywhere else.

Not only are fogs in this region about the most frequent in the Arctic but also about the most complicated in their sources. For we have here three fog-producing factors in a rare combination—the islands in summer generating heat, the sea ice remaining motionless between the islands either far into or throughout the summer, and the sea to the northwest lying partly open, with a great deal of mobile ice. On most coasts you have only two of these three factors, the land and the open sea. There is, however, an almost equally complicated situation in Greenland where you have at a corresponding season the heat-generating coastal strip lying between the cold open sea and the still colder Inland Ice.

b. Special Aviation Problems

We now describe some of the special forms of fog that may be encountered in the Arctic, a majority of them produced by low temperatures.

Water smoke lies over flooded rivers; you normally have to fly at least 500 feet high to keep clear. It looks like the smoke of a small forest fire and does not spread any great distance.

On land a possible source of water smoke is unfrozen lakes. Most lakes freeze over so early in the fall that the weather is not cold enough yet to produce smoke; but Great Bear Lake (and possibly some other Arctic lakes or lakes on the margin of the Arctic) is so deep that it may have open water as much as two months after the freezing of small ponds. Under such conditions water smoke may rise in quantity, though probably not to a great height.

A still more rare source of water smoke is springs that come from a hillside too warm for quick freezing. These need not be warm springs in the proper sense of the word. Of course, warm and hot springs produce, in ratio to their size, very conspicuous smoke. For instance, in Iceland, where boiling springs during summer distinctly give the impression of steam, the same springs in winter will give the impression of smoke, even though the temperature which enables them to do so is little, if at all, below Fahrenheit zero. An instance is in the naming of the capital city, Reykjavik, *Smoky Bay*. It will not occur to anyone to speak of Smoky Bay who has seen Reykjavik only in summer; it is a most natural description to those who have seen the bay on a cold and clear day in winter.

Water smoke is most conspicuous at sea. True, the lowest sea temperatures of the air are only around $-55°$ while land temperatures may drop in Canada and Alaska to $-70°$ and $-80°$, in Siberia to 90° below, when a flooded region would give off in proportion to its area a far greater amount of smoke than possible at sea. However, some rivers never flood; the rest do so only at considerable intervals. But sea ice is constantly breaking, forming leads and holes through the pull and push caused by either the motion of the water beneath the floes or that of the air above them. Accordingly, you practically always have water smoke visible in some direction when you are traveling over the Polar Sea in clear midwinter weather.

Since flyers have apparently determined that river smoke seldom goes much above 500 feet it may be that lead smoke does not go higher; but to sledge travelers the impression is strong that it does rise to a thousand or more feet. However, the columns of smoke often have a flattened top, as do smoke columns on land that are derived from a forest or prairie fire—a kind of ceiling.

One striking difference between sea ice and fresh-water ice is in relation to water smoke.

Practically as soon as a river or lake is frozen over it ceases to have smoke-producing power. If you examine the surface of fresh-water ice, even if no more than an inch or

two thick, you will find it dry. As we have explained in another connection, young salt water ice is damp or wet. To begin with, its own consistency is mushy, or wetly granular, as contrasted with the glass-like appearance and behavior of fresh ice.

The slush on top young sea ice is nearly always at a temperature lower than the freezing point of the sea (27° or 28° F.); but even if it is as cold as just a few degrees above Fahrenheit zero, it is still a lot warmer than air of —40° or —50°. So long as it is wet in consistency it evidently has more power of releasing particles of itself into the air. At any rate, leads will continue to steam and produce smoke long after they are frozen over. During the first day, when the thickness of the mushy ice is perhaps only 2 or 3 inches, the smoking is almost as conspicuous as that of open water. On the second day it is less conspicuous. It does not wholly disappear, if conditions of a chill and clear atmosphere are right, until the ice is so thick that it is no longer damp on top. This thickness is probably somewhere between 8 and 12 inches.

Human-animal fog is of the same nature as the invisible perspiration discussed in Chapter 9. Your normally moist (apparently dry) hand will show as much steam at —60° in calm clear weather as a towel wrung in boiling water shows in a room at 60°. Transfer this standard to other sources of "steam" and you have the basic idea of human-animal fog.

Alaskan and Canadian flyers report that in the early morning, before and around sunrise, with a ground temperature of —50° to —65°, fog is usually or always noticeable over villages. The steam (together with smoke in some cases) make a "ceiling" at a few hundred feet. The fog will disappear if the sun develops heat or if a wind comes up. Flyers, knowing the condition to be local and temporary, take off from within these local fogs and are, of course, almost immediately out of them.

At Fairbanks this fog sometimes extends a half mile or more beyond the limits of the town. When you fly directly above that town nothing is usually obscured, visibility is perfect—you see the town clearly through its fog. But flying at an angle the town is blurred or hidden.

Flyers can pick up a town by the fog bank over it. Finding such a fog bank and shooting for it, you will come either upon a town or upon open water. But the reverse may happen—you may not be able to see a local fog that hides a town. One danger then is that you may think yourself off your course when you are not. For instance, you may plan to identify a river by a town in a certain position on it. If you do not see the town, in apparently perfect weather, you may think yourself on the wrong river.

The houses in one edge of a village are usually visible, for the air will have some movement and the windward side of the town will be exposed. Similarly, an entire band of caribou or reindeer is seldom hidden—you will see at least a few animals at one edge of the herd.

FOG TAILS

On some days Arctic planes will leave a fog tail 15 to 20 miles long that hangs still (straight) in the air, or may become wavy. One flyer setting out after another whose machine has disappeared from view can track the pilot to his destination by following the tail that is hanging in the air. Canadians have reported fog tails 18 miles long in the lower Mackenzie.

Although "spicule fog" appears to be a widely accepted term, it is a bad one. To begin with, what you see, as described below, looks more like a snowfall than a fog—it is as if snow were forming before your eyes and then slowly falling. Perhaps some term could be devised on the idea of "frost flakes."

Dr. Ralph L. Belknap, leader of the Michigan-Pan American Airways Expedition, reported spicule fogs from the Greenland Inland Ice. He gives the conditions under which they occur:

Because of the relatively low air temperatures over the interior of Greenland, the relative humidity is invariably high (i. e., the precipitation point is not far off). When condensation occurs it is most often in the form of ice spicules. Especially during the early morning hours, when the temperature was less than 10° F. the air, although cloud-

less, contained many small glistening particles falling slowly in the nearly motionless air. If there is a slight air movement, the particles have a tendency to collect and adhere to the lee side of obstructions.

On the Inland Ice these particles sometimes were in quantity sufficient to obscure objects usually plainly visible. Such "fogs" develop in periods of low temperature, high humidity, and calm to light winds. Dr. Belknap believes the fog effect is confined to a zone of limited vertical extent (a few hundred feet).

Spicule fogs pronounced enough to be dangerous to airplanes are apparently very rare in all those parts of the Arctic where flying has been developed extensively—are seemingly more frequent on the Inland Ice than anywhere else. It is an indication of how rare the condition is in that there are no reports of trouble from all the flying yet done in Arctic Canada, according to the information of one of the most experienced of Canadian flyers, W. E. Gilbert. Only two Alaska cases are known to Pacific Alaska Airways; but they were serious, producing a heavy coating of frost on the wings just after the take-off or just before the landing so that planes came down out of control.

"BLACK FOG"

Reported as a hazardous fog is the "black bank" which Canadian flyers have found in March low over the ice of the frozen sea in the Mackenzie River to Cape Parry district. It is most particularly dangerous where the coast is flat, and is more noticeable on overcast days. Flying along a flat coast, say in the Baillie Island neighborhood, if you are strange to the country, you might imagine you were approaching an area of high coastline, the low fog resembling a high cliff.

SECTION VI

BAROMETRIC PRESSURES

The following statement on barometric pressures within the Arctic regions is based upon the work of Dr. Harald U. Sverdrup, an explorer of note, a leading authority on Arctic

climatology, chief of scientific staff of the *Maud* expedition, now Director of the Scripps Institution of Oceanography, La Jolla, California. No long series of climatological observations has been carried out in the polar regions but Dr. Sverdrup has collated all the available material. His conclusions are based largely upon observations in the Arctic sea made during the *Fram* expedition in 1893–96 and the *Maud* in 1922–24. To these have been added data from various Arctic expeditions of the last century.

Barometer studies of probable great importance were carried out systematically by the *Papanin* expedition which began its drift at the North Pole late in May 1937, and closed its observations near the east coast of Greenland north of Scoresby Sound in February 1938. Longer continued and systematic were the observations of the *Sedov* which drifted between October 23, 1937, and January 16, 1940, westward north of Asia, generally parallel to the track of the *Fram*, although most of the time north of it. The *Sedov* expedition results, however, are more likely to amplify than to alter those of the *Fram*. So perhaps it is most from the *Papanin* results that we may anticipate changes in the view presented by Sverdrup.

We now summarize and paraphrase what Sverdrup has said on Arctic barometric pressures in his two main publications, Volume II of the *Norwegian North Polar Expedition with the Maud 1918–25, Scientific Results*, Norway, 1933, and in Band II Teil K of the Köppen-Graz-Geiger, *Handbuch der Klimatologie*, Berlin, 1935:

In winter (January) the Atlantic side of the polar sea is under the influence of a low-pressure trough, extending from Iceland toward Cape Chelyuskin, Siberia. On the Siberian-American side the pressure distribution shows a saddle point between the low-pressure sections south of Spitzbergen and over Bering Sea; another saddle point is found between the high-pressure regions over Siberia and Canada-Alaska. Between these high-pressure regions there appears a disturbing zone, within which deep winter cyclones are formed. These, moving in a northeasterly direction, later turn around and reach the Canadian archipelago from the northwest.

In the spring (April), high pressure predominates over the greater part of the polar sea and the Canadian archipelago. During this time of the year the disturbances are much smaller than in winter.

In the summer (July), the pressure differences are very small over the entire region, the disturbances are frequent, but slight. The direction of the wind indicates higher air pressure over the northern part of the archipelago, but this is not borne out by the observations of pressure. All differences are, however, slight.

In the fall (October), a transition to winter pressure distribution takes place, with a saddle point north of Bering Strait. From this month onward strong disturbances again occur.

As in lower latitudes, the greatest number of disturbances occurs in the winter, when the air pressure is generally high. The mean monthly fluctuations of air pressure are here, as elsewhere, greater in winter than in summer.

CHAPTER 4

LIGHT IN POLAR REGIONS

SECTION I

GENERAL

A practical way of discriminating between daylight and darkness is to say that it is not dark so long as a man of normal sight can read ordinary print out of doors. By this definition you would have at the North Pole (at 90° N. Lat.) each year something around seven months of daylight and five of darkness.

We may also consider defining as dark that period when no daylight can be seen anywhere in the sky. On that definition you would have at the earth's pole about eight months of daylight and four of darkness.

It is never pitch dark inside either of the polar circles except where you find a sea without ice, as to the north and northeast of Iceland. In summer, when land in the Arctic usually is black, brown, or green, there is perpetually either sunlight or twilight. In winter, when direct and indirect sunlight are both absent much of each day, the ground is usually white, with a snow covering which so reflects and magnifies whatever light gets to it that, even at maximum darkness, you could probably see a dark-clad man on a white field at least 100 yards away. Maximum darkness will occur when the sky is densely overcast, when there is no twilight, when there is no moon in the sky, and when there are no northern lights behind the clouds. The stars by themselves, then, succeed in transmitting enough light through the densest clouds so that when this is reflected by the snow it prevents that type of pitch darkness with which we are familiar in the nonpolar zones.

Because of the shape of the earth, its relation to the sun, and refraction, there is some daylight at any given moment over about 66 percent of the earth's surface. This means that you would at either pole see daylight, from first trace in spring to last trace in fall, continuously for about two-thirds of the year. There is most daylight per year in the polar zones, intermediate in the temperate, least within the tropics. For refraction increases with decrease in temperature; and while polar zones do not have the most intense cold they do have the lowest average yearly temperature.

The main reasons why there is more effective light in the polar zones than people from outside them expect, are the following:

Air transmits light more easily when it is dry. Chilling the air dries it. The air over the polar zones during winter, therefore, transmits light more perfectly than we are used to even in deserts.

The Arctic is mostly sea, lake, or swamp. Accordingly, less dust escapes into the air than we are used to, and dust-free air transmits light better.

There is not as yet in the Arctic any considerable pollution of the air by the smokes of industry or even by those of numerous dwellings. Forest fires are rare, and volcanic dust has less chance than in most places, although there is a certain amount of vulcanism on the fringes of the Arctic in two sectors—Iceland and the Aleutian Islands. The absence of these smokes contributes further to the clarity of Arctic air.

The sun stays above the horizon for something more than half each year, because of refraction. After sinking below the horizon in the autumn and before attaining it in the spring, there is a twilight brighter through the above-described clarities of the air and which is increased in effectiveness by reflection from the snow.

As said, the stars, least considerable of the sources of light, succeed in delivering a higher percentage of their total product in the Arctic than in the temperate zone or tropics. What they do deliver is increased, perhaps doubled, by reflection from the snow, so that we might say that the Arctic stars give light between two and three times as effective as that of the stars of other zones.

The same increased quantities of delivery and the same multiplication by reflection applies, naturally, to the moon. A rough check has been made with a number of polar travelers, both Arctic and Antarctic, who agree that on a cold, clear midwinter night you get more useful light from half a moon on a snowy landscape than from a full moon shining on a green landscape.

With a clear sky, you can see a mountain range as far by the light of stars and half a moon as you could by sunlight. Several Arctic pilots have written agreeing that you can land an airplane about as safely with half an Arctic moon as with daylight. Some informants have said that, while there is not with half a moon quite as much light as you would ideally want for landing, you are for compensation free from the glare that sometimes interferes with snow landings during full daylight.

Some experienced flyers disagree that the light of half a moon is adequate for safe landings, and feel that moonlight really sufficient is available only for the two or three nights at the immediate full. These flyers, however, are all from Alaska, all have their main experience in the Yukon valley, not on the prairie north of the Brooks Range or on the Arctic coast. This brings out an important thing—that clumps of forest scattered here and there about an otherwise snowy landscape detract from the total reflecting effectiveness more than you would expect. For one thing the moon is usually at a slant so that the trees not only absorb the light which strikes them directly but also throw a shadow over some more of the landscape. Then there are like shadows thrown by rocks and cutbanks while cliffs are usually dark because they are steep. Mountain slopes are not on the average as effective with moonlight as are horizontal landscapes.

A considerably higher percentage of the moon's light is available for human use in northern Alaska than in southern Texas. For in Texas the moon sets every night both while it gives little or no light around the new and when it gives maximum light around the full. At Barrow the moon does not rise at all when it is new; but it does not set at all when it is full. Barrow people lose no light from missing the

moon that has no light to give; they gain a lot from never losing sight of the full moon.

The moon at its full stays above the horizon only between one and two full days at the Arctic Circle. At the North Pole it rises just a little before it is half full; then it stays in the sky through the full until it is a little less than half. If you figure a lunar month at 28 days, you have the moon visible for about 15 and invisible about 13.

A special aid to visibility in the Arctic night is the aurora borealis. At its brightest it may give as much light as the full moon—some say more. However, the auroral is the least dependable of the lights—you never know when it is going to come or fade. But it is at times very useful, sometimes aiding materially throughout the whole night. (When we say "whole night" we are speaking, of course, of latitudes south of 84° N., for below that parallel there is some daylight in the sky even on December 22.)

An advantage of moonlight over sunlight, connected with the absence of glare, is that it throws more sharply defined shadows or appears to do so; and shadows give an airman his one possibility of telling the difference between a level and a rough snow or ice surface when he is coming down for a landing. It is, therefore, a serious defect of auroral light that it never comes from a single focus, like moonlight, and seldom even from a small part of the sky—more often from several points of the compass and occasionally from nearly or quite all of them. Coming from several directions, the aurora throws no clear shadow; if it is very bright it may interfere so much with the moon's power of making well-defined shadows that, for airplane landings at least, the increase of light through the aurora is more of a hindrance than a help.

Section II

SPECIAL CHARACTERISTICS

For the period when the sun is above the horizon the Arctic light requires only a few special comments:

Sunlight reflected from water produces quick and violent sunburn. For like reasons sunburns are quickly produced by

the glare of Arctic snow. For protection, dark veils are sometimes worn.

When the sun is well above the horizon and the sky uniformly though not densely overcast you have the maximum of eyestrain and tendency to snowblindness, as well as the most difficult of all light conditions from the point of view of a traveler, whether walking or flying.[4] On sea ice, or on land uniformly snow-covered, you are literally unable to see anything that is white. For invisibility you don't have to have snow-whiteness, exactly matching the landscape. For instance, a polar bear, in reality yellowish white, may be invisible as he approaches you, except that you see his black nose and will, with that for a key, be able to notice his eyes and perhaps his claws or other dark spots and even a faint outline of his body. Under the conditions where a bear is invisible a hundred yards off, a blue fox might be visible at a mile or more.

We discuss in chapter 11, "Travel," how these conditions may lead to your walking over a precipice or stepping into a crevasse, and we deal there with the precautions that should be taken.

We couple with our general statements on light a group of phenomena pronounced in the Arctic and important for winter travel—water sky, land sky.

We have from the temperate zones and tropics some examples which prepare for the more clear-cut phenomena of polar regions. For instance, when the clouds are just right, you can see the lights of a city reflected in them at great distances, particularly on prairies. In the mountains, even in the tropics, you may, when the clouds are just right, see white patches in the sky surrounded by dark. The white ones are the reflections of glaciers, the dark are over the snow-free parts of the mountains.

The most perfect example of these phenomena, as well as their most useful manifestation to a traveler, is met with when sledge parties traverse the polar sea far from land—nearer

[4] Apparently snowblindness is not contracted by pilots while aloft.

land the same phenomena are present, but in some cases so confused as not to be useful.

Far at sea, then, on a day completely and uniformly overcast, and with clouds at fairly high levels, you have above you a real map of your surroundings. The higher the clouds the greater the area of sea pictured in the sky.

Cloud areas below which level ice is uniformly covered with snow will be a uniform white on your sky map. Broken surfaces with many pressure ridges can themselves never be quite uniformly white and are, therefore, represented above by a slightly mottled appearance. One kind of ice surface, the paleocrystic, has been converted by many summers of rains and thaws into a small-scale equivalent of an undulating prairie. The hollows are choked with snow, the hills that have been swept free of snow are blue in appearance, because, as elsewhere explained, old ice is always fresh and glare. Paleocrystic floes are, then, reflected in the sky by round, oval, or at least not angular, dark patches in a matrix of white.

The sky map shows leads in their full variety of manifestations. Those which are several weeks or months old are smoothly snow covered and are therefore shown by the clouds more uniformly white than any other ice; and so you will discover long ribbons in the sky representing them cleanly. Other leads have ice from one to several days old, and they are represented by sky ribbons of various degrees of darkness. Those leads in which the water is still unfrozen are shown the darkest of all, practically black.

The experienced sea traveler has definite views on every type of ice. Looking into the sky he recognizes those he wants most to avoid, those which are most desirable, and all the intermediate grades. This may be of importance to his strategy. In Chapter 11, Section III, we tell how the traveler chooses and varies his route according to the sky map.

A special type of sky coloring begins to appear in spring when temperatures start running from -20° in the late night to 20° in the late afternoon. The traveler over the northern sea will then begin to notice a general pinkish tinge

in large patches of his sky map, most pronounced in certain places and sometimes giving a definite pattern to the sky. This shows him that the tiny plant known as "pink snow" has begun to develop. (See also chapter 6.)

When you approach land in winter or early spring you see first a general darkening of the sky. This is not as pronounced as if caused by open water. There are certain patterns in the sky map now which you recognize as showing land formations, and there is an amber or yellow tinge due to the bleached grass which sticks up here and there through the snow. If there are in the land sky a few patches as dark as over water, you know they are sandy or rock stretches—at any rate land where the wind has swept all the snow away.

A modification of land sky is sometimes found at sea in that strong offshore winds have carried dust and fragments of rock out upon the ice. There will then be belts and tongues of gradually fading darkness stretching out in the sky map from the denser drabness of the land.

Next after its supreme usefulness to a sledge traveler comes the usefulness of the sky map to the navigator of a ship in broken ice. Looking ahead (always presupposing a suitably cloudy day) you can see where the ice presses against the sea coast and where it does not; you see the leads and open patches and you form some idea of the character of what ice there is.

A flyer passing over the northern sea, having a wider horizon, does not need the map quite so badly as other travelers, but even to him it will be useful. His method of interpreting the map will, of course, have to be a little different since he is likely to be near the clouds and will therefore have a different perspective.

LOW FLYING FOR USE OF SKY MAP

Wilkins, who got accustomed to using the sky map as a traveler afoot on the northern pack, makes a suggestion for a novice in Arctic sea flying. If he is below the clouds and close to them he can make practically no use of the reflected map. In practice on such occasions Wilkins goes down as low

as he can safely; for the lower you are the more accurately and easily you can read the map.

In making this suggestion, Wilkins has in mind chiefly the problems of landing. If you are flying a craft with wheels or skis and want to make a landing, or think you may need to do so, you will select from the sky map patches that are uniformly white—not mottled or peppered to indicate the rolling, glare paleocrystic ice or recently fractured ice of whatever age. If in a flying boat, you look for uniform black patches that show open waters free or nearly free of drifting ice fragments; if none is seen in the map then, alternatively, you seek a uniformly white patch and make a snow landing.

CHAPTER 5

ANIMAL LIFE

SECTION I

WILD ANIMALS

This chapter does not pretend to give a complete list of the animal life found in the Arctic, nor to give all of the scientific facts that would be necessary in a zoology volume. It does list those animals which are important in the economy of the Arctic hunter, with brief discussions of the outstanding characteristics of each.

The so-called Barren Ground caribou is found winter and summer on the north coast of the most northerly islands in the world, with the exception of Peary Land, from which they seem to have been exterminated by wolves, and certain small islands which they never seem to have reached—no doubt from inability to traverse the sea, ice-covered or not, that separates these from other lands. Its range extends south at all seasons down into the forests of both the Old and New Worlds. Among islands seemingly never reached are the Franz Josef group and Jan Mayen. They may never have reached Wrangel Island and the tiny islands discovered by the De Long expedition—Henrietta, Bennett, etc.

Estimating the numbers of caribou is so difficult that guessing is perhaps a better wording. Those of Arctic and sub-Arctic Canada have been estimated at all figures from one to twenty million, with five million perhaps a reasonable guess. In Alaska there might be from one-fifth to one-third as many as in Canada. In the Soviet Union there are not as many as you would expect; or, rather, the small estimates are due to the occupation of what were the wild ranges by the domestic animals, under the name of reindeer. Perhaps in

spite of all the vastness of northern Siberia there may not be as many wild caribou there as in Canada.

Caribou and reindeer are of one species. We have said of reindeer that they vary from the smallest, which are represented by certain breeds of Lapland, to the largest, which are probably the Tungus—with the biggest Tungus animal at least twice as heavy as the smallest Lapp. The range is probably somewhat smaller with a wild caribou. They are tiniest in northern Ellesmere Island and northern Greenland, the Peary Caribou. They grow on the average larger as you pass southward and southwestward through the Canadian archipelago. They are apparently somewhat larger in northwestern Arctic Canada than in northeastern. Perhaps largest of all are those which spend part of the time in the forest and part on the prairie in central and northern Alaska.

Then we have the question of whether there is a difference between prairie or "barren ground" caribou and woodland caribou. There is no doubt that those prairie caribou that go into the forest mingle with the forest varieties, which may account for the gradually increasing size from the Peary caribou south and southwest—assuming that the woodland caribou is "naturally" the larger.

It is not possible to say what are the boundaries between woodland and prairie caribou—unless by agreeing that there are not any, or that they are somewhere in the Arctic or sub-Arctic forests. The southward limits of the woodland caribou are found in the United States—in Maine, Minnesota, Idaho, and Washington.

MIGRATIONS

In certain parts caribou movements are to an extent seasonal and have somewhat the character of a real migration, though not so strictly as we used to believe. Nor are the directions as regularly north and south as those of properly migrating birds.

On the Canadian Arctic mainland and Victoria and King William Islands there is a fairly regular movement southward in the fall and northward in the spring, but not all of the caribou move out of Victoria Island in the fall and a few

within the island appear to move north. On the Canadian mainland south of Cape Parry, in the autumn of 1911, Stefansson found that the caribou moved south around the earliest snowfall but started moving north again well before Christmas—thus were moving north during a period when the cold was increasing, and would continue to increase for another two months. In Banks Islands, so far as there is a movement, it appears to be south in the spring and north in the autumn—certainly Stefansson found caribou more numerous in the northern than southern end of Banks Island in the years 1914–17. M'Clure reported the Banks caribou behaving just that way a half century earlier; for they were numerous around the Bay of Mercy in midwinter.

There is no sure way of telling when "migrating" caribou will arrive or just where they will pass. One thing that is known to affect the direction of migration is the freezing of a lake—if caribou arrive before it freezes the herd will split to right or left or else the whole of it will be deflected to one side; if they arrive at a lake well frozen they make straight across. They might also be delayed by the late freezing of a body of water—hardly by a river, perhaps by a lake or a bay, certainly by a wide stretch of sea. Thus the time of arrival, if the herd does arrive, may be varied a month or two by early and late falls; the "migration track" may be deflected 50 or 100 miles by unfrozen lakes; or movement may be in effect stopped—in the sense that a herd does not arrive at all one year in a district to which they usually come.

A second factor that tends to direct caribou movement, whether they are a "migrating" or simply a grazing herd, is the direction of the wind—they tend to feed and to move up into the wind, but do not always do so.

The reasons for deflection and delay by unfrozen lakes is obvious; the reasons for control by wind are perhaps two: that caribou depend upon their sense of smell for warning against their chief enemy, the wolf; and that in a blizzard their eyes will be kept reasonably free of snow by the wind while they are facing it, but are going to be filled with eddying snow if they turn away, particularly if they do so while grazing.

We have spoken thus far of a herd of caribou as if this

were a natural and inevitable formation. It is nothing of the sort. Caribou do tend to be gregarious. But one year they will be found in a certain district in bands few of which are above a hundred, while in the same district perhaps two or three times a century they are in a single herd as large as a million. We take a hypothetical case for illustration.

Suppose, for instance, that there are a half million caribou in Victoria Island which "intend" to move south but are delayed perhaps a month by storms and open water from crossing Dolphin and Union Straits and Coronation Gulf to the mainland. Assume that there are 250,000 caribou feeding on the mainland west of Coronation Gulf and another 250,000 on the mainland east of the Coppermine. It might be that the mainland half million would be restrained from moving south by prevailing northerly winds into which they face, or by some other natural condition.

If both these quarter millions begin moving south about when the half million are crossing from Victoria Island, you still do not have your million in one continuous herd unless something happens that focuses all three groups to a point. This could be that the bands east of the Coppermine are deflected westward by a series of occasions when they strike a lake in such a way that it "appears to them more logical" to turn west for the detour and that the bands west of the Coppermine are similarly deflected eastward; or perhaps these two deflections might result from a southeasterly wind west of the Coppermine and a southwesterly one east of it.

We have just dealt in a lot of ifs; that is correct, for it takes a lot of ifs to explain the two well-known facts that usually caribou are found in bands of only a few hundred or at most a few thousands, but that once or twice in each human generation there is a credible report of incredible moving swarms.

HERDS OF A MILLION CARIBOU

There was, for instance, the case reported by members of the second Stefansson expedition, that a herd, which required four days to pass, moved south across the headwaters of the Dease the fall of 1911. First there was a day of

scores of bands ranging from dozens to hundreds. Then there were 2 days of a moving ribbon of caribou four miles wide that practically covered the land from sight. Last was a fourth day of scattered bands. According to report these animals sometimes trotted or galloped, sometimes walked, and sometimes stopped to graze, and sometimes lay down. The estimate was that a resulting average speed was that of a slow walk, say a mile and a half or 2 miles per hour. The herd must have been several hundred thousands and may have been a million. It was comparable in numbers to the great buffalo herds of the Dakota-Kansas region a hundred years ago.

Caribou movements are similar, with the irregularities of them similar, in the Old World.

That grasses are a preferred caribou food in summer but lichens in winter may be a key, or at least one of the keys, to the "migrations." It has been found with domestic caribou, named reindeer, that they have a good memory for localities, amounting to a "homing" instinct for districts in which they have lived. An animal that can remember its home can presumably remember the kind of food it ate in a given district. This seemed to Stefansson the probable explanation of the southward movement in Banks Island toward the end of winter and the northward movement toward the end of summer. For it appeared that grasses were the chief vegetation in southern Banks Island; grasses were the prevailing vegetation also in northern Banks Island, but there seemed to be more lichens up there, and this (perhaps) enticed the caribou north in the fall.

The suggested Banks Island explanation does not argue against a southward movement on the mainland of Canada in autumn, if it be thought that the animals "plan" to go all the way to the forest; since it is probably true that there are more lichens available in the northern forest margin than on the prairie just to the north of it, which is primarily a grass land.

So far as we can generalize, the continental movements are, on the average, seasonal, more likely to be south than otherwise in the autumn and more likely to be northward in the spring. But on the islands, with the chief exception of Vic-

toria and King William, many of the movements are not seasonal and those which are seasonal, such as Banks Island, may be the reverse of the movements of migratory birds—may be north in fall and south in spring.

Shed horns are the most reliable indication of caribou movement. The old bulls shed them around midwinter, younger bulls later in the winter, and cows not until spring. Thus the age and sex groups leave behind clues to their seasonal movements that can be read hundreds of years later. Stefansson found the shed horns of old bulls, indicating midwinter residence, on Isachsen Island and on the other Canadian islands in the same latitude (77° to 80°) discovered by his third expedition. He saw animals there both fall and spring, accounting for two more seasons and virtually proving that they were there the year around.

Among the northern caribou in the New World the smallest are found in Greenland and generally to the northeastward. The largest, southwestward in Alaska, weigh up to 400 pounds. Approximately speaking, some of the caribou near the Endicott Mountains of Alaska are twice as large as the Peary caribou of northern Greeland.

Roughly, there is a similar variation in color. The Peary caribou are lightest and the Alaskan darkest. There are no albino species of caribou and albinism must be very rare. Stefansson never saw a white, partly white, or spotted animal in tens of thousands of caribou during ten years in the Arctic, though he frequently studied large herds through field glasses.

The fatness schedule for caribou varies slightly by districts—by climate. Generally a bull more than four years old has practically no fat at the end of the rutting season, which may be some time in October. There is no appreciable fattening through November and December—even the bone marrow contains little fat. In January the marrow has considerable fat, and fat begins to show behind the eyes and around kidneys and intestines. The increase in fat is continuous through February, the coldest month of the year, and through March and April, still at a slow rate; there is a rapid fat increase through May, June, and July until by middle or late August a bull of 400 pounds live weight may have more than 75 pounds of fat (suet). About half the total fat is in a

slab along the back which extends forward along the neck and down behind along the haunches. The thickest parts are just a little forward of the tail, but not straight in front of it—2 or 3 inches to either side. Careless hunters sometimes describe this slab as being four inches thick but it is probably seldom thicker than 2¾ inches. In butchering it is Eskimo and forest Indian custom to remove or, as they say, skin off the slab of fat, which may weigh 35 pounds, and more in extreme cases.

A bull of 2- or 3-year age gets fat along about the same cycle as an older bull, except keeping a month or so behind in schedule. In proportion to total body weight, the younger the bull the less fat.

The fatness schedule for cows is nearly opposite to that of bulls. True, a cow as well as a bull is fat in the autumn; but in winter she loses fat gradually during the time that the bull is gaining it gradually. Proportionately even fatness of mature bulls and mature cows may occur somewhere around February or March. Thereafter the bulls are fatter in proportion to total weight. The cow does not lose all her fat until at the calving season, which may be in April. Indeed, she is likely to be thinnest somewhat after that, in late April or in May.

The fat cycle for the domestic animal, the reindeer, is about the same as for the caribou, except that steers have a cycle that resembles that of the cow. Probably steers have more fat in proportion to body weight than bulls.

It is the view of Eskimos, and of whites who live on an exclusive meat diet, that the lean tastes better in proportion to how fat the animal is. This view is strongly held only by those who do not use seasoning in their food—who use no salt, pepper, onions, and the like. Those who use seasoning judge meat from a somewhat different point of view—are likely to prefer a cow or a young bull when those who do not use seasoning prefer the meat of an old bull.

Among caribou, bulls never get very old, probably not older than 6 or 7 years. This is because of the speed ratio between ages and sexes. When a wolf pursues caribou he catches the slowest runner—the animal that drops behind. Big and fat bulls are slow for those reasons and additionally slow in the fall through carrying heavy antlers. If a caribou calf lives to

be 2 or 3 days old it is not likely to be killed by a wolf until it is 5, 6, or 7 years old, the males being killed somewhat younger than the females, for the reasons given. Practically no caribou attain an age of 9 or 10 years. They do not closely approach a time when they might die of age. The causes of death among them, in order of increasing frequency, are accident, human hunters, wolves.

There are few if any things manufactured that can equal caribou skin for clothing. They are at their best from mid-July to about the middle of September, depending on age and sex and on the purpose for which the skin is wanted. Later than September the hair begins to get brittle, and eventually loose; spring it is so very loose that the skin is practically worthless for clothing. The hide is then at its thinnest, ideal for parchment—to make Eskimo-style windows. During June and July the caribou have a more or less patchy appearance, due to bunches of loose, faded old hair remaining in places. Summer skins are often badly perforated by a species of botfly. (See more detailed discussion of use of skins for clothing in chapter 9; for description of damage by botflies, see Sec. IV, this chapter.)

In many districts the natives live for long periods almost exclusively on caribou. Eskimos and experienced whites can pick out from a herd the fat caribou by observing the shape of the horns. This is merely the ability to distinguish between the sexes and ages in a herd at the different seasons.

MUSK OXEN

There is no logical reason for calling this polar animal musk ox. The origin of the name is obscure. It may have been some early English navigator who was a better sailor than zoologist and misidentified him with the musk deer of Asia. Or possibly he was more of a trader than a scientist and wanted to convey the impression that he had discovered a new commercial source of the costly perfume of our ancestors—a trick with many parallels in early exploration.

Scientists gave the beast a fairly descriptive name, *ovibos* or sheep-cow. This is what he is to the casual observer—a cow (or bull) with a coat of wool. Sverdrup, having eaten the meat and drunk the milk through several years "without

ever detecting the flavour of musk from which they are supposed to derive their name," calls them polar oxen. Other travelers refer to them as cattle, among these the most famous British explorers of the eighteenth and nineteenth centuries, the men who discovered and mapped the chief lands where this beast has been found. Stefansson has suggested popular use of the technical name, ovibos.

In times geologically recent the musk ox ranged at least to Kentucky in the New World and correspondingly far south in the Old. There is apparently no record that live animals were sighted in the Old World by Europeans or by natives whose tradition has been preserved, even in northern Siberia. Two hundred years ago they ranged halfway south along the western side of Hudson Bay, into the edge of the forest. During the nineteenth century they came nearly or quite down to the north shore of Great Slave Lake. In the decade 1860–70 what was apparently the last band of them was killed in Alaska, inland south from Barrow. None have been reported by Europeans between Barrow and the Mackenzie River. In the early Hudson's Bay Company period, a hundred years ago, they came approximately as far west as the east bank of the Mackenzie. When American whalers wintered at Langton Bay, around the turn of the century, musk ox were killed just a little to the southeast.

When Stefansson was there around 1910 a few were still surviving north of Bear Lake and west of the Coppermine. Today live animals are found on the Canadian mainland only in the northeastern part, chiefly around a game sanctuary created for them on the Thelon River west of Chesterfield Inlet, where they are variously estimated at from 300 or 400 to 1,000—these being the supposed totals both at the sanctuary and in all outlying districts. All killings have been prohibited for some years past, but there are doubtless surreptitious ones.

In Banks Island there were thousands of musk oxen around 1850, when the first British explorers were there—the bones are now scattered over that island somewhat as buffalo bones were on a Dakota prairie; but the last living animals were killed either in the first or second decade of the twentieth century. There may still be a few along the northern edge

of Victoria Island, with none in King William, and probably none in Somerset and Prince of Wales Islands. There are a few score in Prince Patrick, perhaps 4,000 in Melville, doubtless several hundred in Bathurst. It is anybody's guess how many there are in Heiberg and Ellesmere Islands; but they are probably the richest musk ox territories in proportion to area—with perhaps the exception of Melville. Peary found them at the north tip of Greenland, in Peary Land—apparently no more than a few hundred. It used to be thought that northeastern Greenland, from Peary Land to Scoresby Sound, would have only another few hundred; but following 1930 reports of Norwegian hunters would seem to indicate that the hundreds of the estimates should be replaced by thousands, with 10,000 a probable outside limit.

In 1934, Dr. R. M. Anderson, chief biologist of the National Museum, Ottawa, gave 500 as an estimate of living musk oxen in mainland Canada and 13,000 for all Canada—therefore 12,500 for the Canadian Arctic islands.

The usual explanation for the shrinkage of the musk ox range from the central United States northward to Arctic Canada, and the like in the Old World, is that they belong in a cold country and that they followed northward the retreat of the ice at the close of the last Ice Age. However, these animals have lived to a normal old age without special care for their health in zoological gardens of New York, London, and other cities, feeding on clover hay and other things not particularly similar to their present northern food which is in the main sedges, grasses, and small bushes in places like Melville Island.

A more likely explanation of the disappearance of the musk ox in ages past would seem to be that the rule which now holds has always held—that the permanent ranges of hunting man and of the musk ox never overlap.

The musk ox has a perfect defense against all northern predatory animals except the grizzly bear, which has been successful in killing them in Alaska during the recent domestication experiments. Wolves they do not fear at all, nor do wolves attack them unless they find an animal by itself, which seldom happens except with very old beasts that have "lost the instinct of the herd," and are wandering by

themselves. When attacked they form in a circle or group with the biggest animals on the outside, standing shoulder to shoulder with heads out. A thrust of their horns or a blow of their feet is dangerous; but perhaps the deciding factor is the heavy wool around the neck which would fill the mouth of a wolf and prevent his teeth from doing harm.

But this perfect defense against wolves is the reverse of defense against hunting man. Bows, arrows, and spears were no doubt invented 20,000, 30,000, or 40,000 years ago. Ever since those days nearly every band of musk oxen has in effect committed suicide by not fleeing but standing up against man to fight.

It seems probable that the newest bones of the musk oxen from the United States are not older than the oldest Folsom points and other weapons of North American man 15,000 or 20,000 years ago. It was probably Folsom man and contemporaries, or possibly their predecessors, who began exterminating the musk oxen from the northern United States and then from southern Canada 10,000 to 30,000 years ago.

Musk oxen are in chief grass eaters. They are, therefore, to be found in the grassiest country which, other things being equal, is also the most nearly level and the lowest. If born on an island, such as Melville, they will almost certainly die there—as against caribou, which move through hundreds of miles, swim rivers, lakes, and even an arm of the sea, and travel freely over ice, whether salt water or fresh.

Anyone who has herded ordinary cattle knows that they tend to rove in search of pasture. Musk oxen here differ squarely. They fill their paunches with the vegetation nearest them and when satiated they lie down. After 2 or 3 hours of rest they get up again, commence feeding in their immediate vicinity, and lie down a second time when no longer hungry. They do not move on the average more than 2 or 3 miles a month. In their march they crop the grass down fairly close and browse on shrubs, moving chiefly in one direction until they come to a patch devoid of vegetation. They then march till they come to the nearest meadow where they stop and resume their systematic slow progress at the rate of a few rods a day.

Musk oxen are peculiar among animals in that they seldom attack, neither do they usually flee. Occasionally a frightened herd will run away, in which case they are more difficult to overtake than caribou. But commonly when alarmed they will run to the top of the nearest small knoll and make a defensive formation (circle, square, triangle, irregular) with the big animals outside and the calves in the center. If danger is approaching from one side only, they may form in two or three lines, with the biggest animals in the front rank and the smallest in the rear. Their central idea is defense, though they may charge upon occasion. Two animals may charge together but a whole band has probably never been reported to charge in a body. Usually they charge singly, each one making a short rush of from 10 to 15 yards, then whirling, running back to the herd, facing about once more and backing into line.

The live weight of grown males perhaps averages 700 pounds. Very large and very fat males perhaps go to 900—that estimate is occasionally seen.

The musk oxen fat cycle does not differ nearly as much as with caribou by sex or by age groups. Generally both males and females are least fat in midsummer, but they are seldom as skinny as caribou get, except in case of extreme age. They begin to increase their fat around the freeze-up, gain steadily through the winter, and are fattest in late winter. As the season warms they begin to lose. It has been assumed rather than proved that this is for two discomfort reasons—they are too warm in their extremely heavy coat of combined hair and wool, and they are uncomfortable through carrying around a heavy matted fleece that is frequently soaking wet, first from spring snows melting and later from rains.

The musk ox furnishes meat which is practically indistinguishable from beef; it is also a possible source of milk supply. (See further discussion below in Section II of this chapter; also in Chapter 8.)

The entire body of the musk ox is covered with long, straggling, stiff black hair, in nature similar to the mane of a horse. In the roots of this hair grows wool. The wool is shed every spring but the hair is never shed. Through the

autumn and early winter the wool gradually thickens and by spring it bulges out all over the body, especially on the shoulders. In April and May the wool is shed. They are short-legged animals and when you have a side view of them at the shedding season frequently the legs cannot be seen at all for the curtain of wool that hangs to the ground. The wool drags in long tags after the animals as they walk, and wisps of it can be picked up from the ground.

NORTHERN MOUNTAIN SHEEP

The white sheep probably never ranged east of the Mackenzie, although they are said to be still fairly common in the mountains on the west side of the river from Fort Norman to the west side of the delta. The Endicott Mountains, or that branch of the Brooks Range which runs northwest from the western edge of the Mackenzie delta, are about 12 miles from the coast at Herschel Island, and 75 or 100 miles from the coast of the Colville, the largest river flowing into the Arctic in Northern Alaska. Sheep were formerly numerous on the heads of nearly all the rivers on the Arctic side of this mountain divide, at least as far west as the Colville. Before whalers started wintering at Herschel Island, in 1889, they were not much hunted, since caribou were plentiful; but when the caribou were almost exterminated the Eskimos gradually occupied one mountain valley after another until the sheep became too scarce to be an adequate food supply. It was no doubt in a similar way that sheep had earlier been nearly or quite exterminated from the Brooks Range west of the Colville.

Although the rocky slopes where the sheep feed look pretty barren, they manage to find enough to eat. The stomachs usually contain grass, sometimes moss. The natives say the sheep do not browse on willows, although they often descend in summer to where the willows are. In winter they usually keep to the higher ridges where the snow is less deep, feeding through the snow which they push aside with the nose. In summer they sometimes go up on the ice-capped mountains when mosquitoes get very bad on the lower ranges, but they come down again toward evening for food.

Sheep are singularly unsuspicious of danger from above, although they are continually on the alert for enemies from below. Their eyesight is keen, the scent and hearing acute, and it is difficult to approach them from below. The hunter therefore endeavors to work around some adjoining ridge or to ascend some creek valley and approach from above. In this manner natives sometimes get within 15 or 20 yards and kill several out of a band.

The habitat of mountain sheep prevents hunters from using them as a side line to other game; those who hunt sheep must depend on them more or less exclusively for the time being.

Eskimo mountain sheep hunters make their clothing, tents, and snowshoe lashings of sheepskin. Their families subsist almost entirely on its meat. Although the outer hair is brittle, only the ends of the hairs break off, so that a garment of mountain sheep may be warm a full winter, sometimes longer.

WOLVES

The typical Arctic wolf is light tawny-yellowish in color, with a few black hairs intermingled along the median line of the back. The usual Eskimo belief is that light wolves are old wolves, but dark females have been seen with white cubs.

Wolves prey on caribou, on small beasts, and on birds. They are usually found where caribou are found. They range along the northern sections of both the Old and New Worlds beyond the treeline, on the polar islands, and have been reported, though in small numbers, from the northern part of Greenland.

Since they follow the caribou, wolves occasionally go south into the forests or north out on the ice; they seem to prefer the prairie between the treeline and the polar shore.

In the polar regions of both the New and Old Worlds wolves aggregate tens of thousands.

The wolf pack, as described in fiction and in news dispatches, does not exist. Stefansson has for years traced every yarn of this nature in the press, whether from Roumania, Siberia, Canada, or wherever, and in each case the story of the sleigh pursued by wolves (where the parents

throw one child out to save the others, or the husband his bride), the farmhouse attacked by them, and so on, were proved without foundation. Interested in learning why such dispatches were carried, he was told that wolf stories were expected by newspapers every so often and were always believed if the locale was sufficiently far away. Many newspapers pay space rates, or used to, on whatever they print.

Others, notably E. W. Nelson, former Chief of the United States Biological Survey, have traced numerous wolf pack stories, always finding them either inventions or based on a misunderstanding. Stanley P. Young, chief of predatory and rodent control of the Survey, is carrying forward the work of Nelson, with similar results.

As will appear below under Psychology of Wolves, the pack stories are alien to their nature. The largest band you will ever see is perhaps 8 or 10, a single family of parents and partly-grown cubs. Apart from these family groups, wolves hunt singly or at most in pairs.

As said, wolves are the chief enemies of the caribou. Ir the northern islands, in every season except summer, caribou furnish 99 percent of their food, mostly old animals, with a few very young calves. As explained already, young adult caribou are too fleet for them, and musk oxen have perfected a defense. Wolves may follow herds of musk oxen, but they get only beasts almost dying of old age, a very few calves, and some cripples—chiefly animals that break a leg. With caribou they occasionally resort to the strategem of two wolves working simultaneously on one deer, one pursuing and the other trying to head off their prey. Foxes are snapped up as appetizers.

It is a common belief that seal blubber is no bait for wolves, that they will not eat it. This may, however, be just superstition; for Stefansson came upon a wolf who was eating a seal he had just killed—no doubt having surprised him asleep at his hole.

It is probable that wolves cannot kill polar bears and that they never try. In any case, the meat is so strange to them that while they will gnaw meatless bones of musk oxen, and dry hides, they will leave untouched caches of bear meat, either because they don't get the idea that bear

is food or else (more probably) for the reason given under Food Prejudices of Dogs—in Chapter 12, Section IV.

Wolves are also the enemies of sledge dogs, and so strong and fleet is a wolf that he can carry off (according to report and belief) a dog that weighs almost as much as he does.

It would seem reasonable that wolves would not be afraid of any living thing they find; for practically their only danger arises from failure to find something. They can run faster than all the animals that are more powerful and they are more powerful than any animal (if there is one) that can run faster. This would make it seem probable that a wolf would run frankly up to any creature he sees—he has a right to believe that if the animal is dangerous he will be able to avoid it easily. But the northern wolf shows no such self-confidence. Singly or in pairs they will circle to within 150 yards, but a strange scent (that of man, for instance) sends them loping away. A family party, especially if the cubs are well grown, will occasionally approach a little closer.

Although wolf furnishes a palatable and wholesome meat, it is not an important source of food supply for hunters. The beast is wary and you seldom get a shot. Then the cartridge which kills a wolf, yielding less than 100 pounds of meat, might better have been used on a caribou, giving several hundred pounds. However, it has been a rule of traveling parties of the Stefansson expeditions who were living by hunting to shoot wolves upon opportunity. No smaller animals are shot, the food return per cartridge being too small.

Eskimos use wolf fur for trimming and, if it is of the fashionable shade, they prize it even more highly than wolverine. These skins must be well furred, with the hair black-tipped. When cut into strips it should show: first a dense layer of fur next the skin, then a band of whitish fur, and last a peripheral band of black. These strips are used for a sort of aureole around a hood; less desirable pieces trim sleeves of coats and are used as pendants.

FOXES

The white fox is found almost everywhere along the Arctic coast but seldom goes far inland in any numbers.

In summer most or all white foxes are on land, having their young, living on birds and small animals. In winter 90

percent of them leave the islands and the mainland, going north rather than south. What they mostly do is to leave the land for the sea ice where they subsist on remnants of seals that have been killed and not completely devoured by polar bears.

Foxes have been reported as small as 5½ pounds. The usual weights are 8 to 14 pounds.

Foxes that go to sea, as above, live exclusively on seals that are provided for them by the polar bears—see below in our bear discussion. Along shores they live on the carcasses of such dead whales as they find. Those foxes that go inland to brush or forest country live on rabbits, ptarmigan, and other birds. When they are all ashore in summer they live on lemmings, eggs, and nesting birds chiefly.

It is not definitely known whether foxes will abandon a seal when they have had one feed. Likely they do, for that is how they behave on land. When a hunting fox is particularly successful with lemming, for instance, it will kill one after another of these and bury each, seemingly with an idea of coming back—an idea which is probably never carried out, for it is likely that if a fox eats a buried lemming it will be one which it has discovered that was killed by another fox.

Foxes will sometimes break into food caches but losses from their thieving are on the whole slight.

Much has been said about their wisdom, but in the north they are (depending on your point of view) stupid or trustful. A fox that sees you is very likely to come up to examine you more closely. If he finds your trail, he may follow it till he catches up with you. He is one of the most easily trapped of fur animals.

The flesh of foxes has been compared in taste to that of rabbit by Hearne, and to young kid by Lyon. Eskimos frequently eat it, and so do a few whites who are not swayed by the customary European food taboo.

The white fox is the staple fur of the Arctic coast, a medium of exchange in many districts. In summer the skins are bluish-gray, maltese color on back, head dusky mixed with silvery white, belly dirtyish yellow. Skins rarely become "prime" (pure white with long hair) before December, and the hair usually begins to get loose by the last of March.

The blue fox coloration of the white fox is rare east of western Alaska—about one blue for each hundred white (the blue and the white are color phases of the same animal). By selection under domestication blue foxes have been evolved that breed true to color.

The red fox (with its variations through rufus, cross, silvery-grey and black) is rare north of the northern limit of trees—it is a forest animal of little consequence as a potential source of food.

BEARS

Classifications of the numerous species and subspecies of bears, some of them based on technical characters which cannot be readily recognized by the layman, are often confusing and misleading. For purposes of simplicity we here consider the northern bears under two main groups—the polar bear and the grizzly. The polar bear we discuss in more detail, since the others are likely to have little importance for the users of this Manual.

The polar bear (*Thalarctos maritimus*) is of a uniform white or yellowish white color, with a dense oily fur that nearly covers the soles of the feet. It is probably the largest of all bears, though this distinction is disputed by those who claim the honor for the big brown Alaska bear (Kodiak bear). The heaviest weight of record is 1,600 pounds for a male.

The white bear is a circumpolar cosmopolitan, inhabiting every part of the Arctic Sea in the Old World as well as the New. They are found on the adjoining land but seldom very far from sea ice—except in connection with hibernation. (See below.) In winter they may appear anywhere along the coast, but in summer their occurrence depends largely upon the nearness of pack ice. Along the Arctic coast of Alaska, east of Point Barrow, they are not very abundant, nor on the coast east and west of the Mackenzie Delta. Numbers are annually killed near Cape Bathurst. They are abundant around Cape Parry and the southern end of Banks Island, but very rarely pass through Dolphin and Union Strait into Coronation Gulf. Occasionally they follow the shore line of Hudson Bay as far south as James Bay; on the Atlantic side they have been taken in Ungava and along the Labrador

coast; they may be found on any Greenland coast; and similarly for the Soviet sector of the Arctic. They are in plenty on island shores in such groups at Spitsbergen and Franz Josef. Generally they are numerous where two conditions meet—many seals and much ice that is frequently broken to show open water between.

In most land bears both sexes hibernate. In polar (sea) bears only the female hibernates and seemingly only when she is to have young. Usually they go inland for this purpose, sometimes 20 or more miles. A few perhaps hibernate on the sea ice, on paleocrystic floes—that is inferred from such things as a visit of a mother bear with the small cubs to the Soviet drifting camp when it was right near the North Pole. The young are born around midwinter, usually two but never more than that, and are incredibly small and helpless. Only after 3 or so months is the mother able to leave the hibernating place with them.

"Hibernating" is the word for the Eskimo idea of what the polar bears do, but that may be just from analogy to grizzlies with which they are familiar. Possibly there is no real hibernation. Stefansson has picked up many stories of polar bears being discovered in their dens but never one of their being in a stupor, as grizzlies frequently are when so discovered.

The seal is practically the one food of the polar bear. It is disputed whether they stalk and kill walrus; if so, their prey would be only the very young. Occasionally polar bears eat from a whale carcass if they happen upon one on a beach, and they are said to eat the eggs of birds when they find them on an Arctic shore. These items, however, form so small and merely incidental a part of their diet that it is still practically true that the polar bear lives exclusively on seals. These they hunt indefatigably, stalking them with patience and skill and moving when the time comes to pounce with speed and lithesomeness that grizzly and black bears do not approach.

We said when discussing the white fox that most of them spend their winters at sea and that they depend for their food on the polar bear. To a limited extent bears also provide sea gulls with food; the important difference is that the foxes would starve to death except for the bears but that

the gulls are able to take care of themselves by feeding in the leads—mainly on shrimps.

The food habits of the polar bear, as attested by those who have studied them on the sea ice far from land, are difficult to reconcile with the ordinary theories of the dietitian who says that protein is required to renew body tissue—that fat serves as a fuel but not as a body builder. For the bears eat chiefly fat, or seem to.

When a bear kills an ordinary seal he usually gets an animal weighing anything below 200 pounds—he may get a 600- or 800-pound bearded seal. A number of cases are on record where a traveler has come along after a bear killed and fed from a seal but where as yet the foxes and sea gulls had made no inroads. If there were several bears together, as, for instance, a mother with two yearling cubs, nearly or quite the whole seal may have been eaten. But if only one bear was concerned he usually eats only blubber and what skin there is that covers the blubber he eats. In some cases he has eaten in this way about a third or a quarter of the hide, but that is practically the only protein, although there is of course a little blood in the fresh blubber. There is no evidence that the bear has sucked blood—anyhow, it is probably more folklore than natural history that carnivorous animals suck blood. We have, then, in the bear a feeder who apparently consumes no more protein than what is practically inseparable from the fat he wants.

There may be, however, an explanation in the behavior of the bear subsequent to his meal. He then walks off a few or a few dozen yards, lies down and goes to sleep. When he wakes up he apparently still has a feeling of satiation; at any rate, he pays no attention to the seal carcass but walks off in some other direction. It may be that while he slept all the lean and fat, along with the entrails, everything except the bones, has been eaten by foxes, by sea gulls or by them together. But since it may also be that whatever he did not eat himself is still there, it seems clear that he goes off because he has no desire for or interest in food.

But this bear may have poor hunting luck the next few days. He sniffs the air wherever he goes. In 2 or 3 days

he may find himself passing to leeward of the remains of a seal, more likely one killed by another bear than by himself. Now he is hungry, goes up the wind, and eats whatever he finds. If there is lean still on the seal he eats that, and now has to eat bones with the lean for the whole is frozen into one equally hard mass. If nothing is there except the bones he will eat those, even the head. It may be this feeding on lean and bones that predisposes him to making an exclusive meal of blubber when next he gets a seal.

As the bear travels, one, two or more foxes are following along behind him, sometimes close up, sometimes far behind. They may even run around him and ahead of him—they are playful and unconcerned, treating the bear as they sometimes do a man on shore. When the bear secures a seal the foxes stand at a not very respectful distance, perhaps occasionally dashing in, hoping to get a mouthful. Ordinarily the bear keeps them at bay as long as he is feeding, sometimes with an occasional blow of his paw—that misses, or else there is a dead fox. If the season is winter the foxes eat everything that the bear leaves except the bones—their small teeth seem unequal to at least the harder bones.

If the season is spring or autumn it may happen that both foxes and sea gulls are waiting for the leavings of the bear; the gulls do not follow the bears as they travel, but they have good eyesight and come from afar when they see him eating. They flutter around, or they settle on hummocks or on the water of a lead. When the bear goes off for his sleep they come nearer but are in the main kept at bay by the foxes. However, towards the end of their feast different foxes may drag parts of the seal away. Then a gull may have a chance, either at the main carcass or at a fragment that a fox has dropped.

During the summer when the foxes are on land, the sea gulls will have an opportunity to eat on the average three-quarters of every seal that is killed by a polar bear—to eat all the bear leaves. It is, as said, only for short periods in spring and autumn that fox and gull cooperate on the scavenging. For just as there are few or no foxes at sea in midsummer so are there few or no sea gulls there in midwinter—almost certainly none; for they have not been re-

ported from the midwinter period, and we think we know that they could not live at sea during the coldest month.

Polar bears are successful chiefly in securing seals that are basking on the ice or swimming in open leads between floes. As explained in Chapter 13, only man is able to secure seals that are living in their holes under old floes of great extent. Since polar bears are powerless to break through heavy old ice, they will never be found in such areas. The absence of polar bears from a locality does not, then, mean that seals also are absent, although such reasoning has been common by writers on the Arctic.

DANGEROUS TO MEN AND DOGS

On shore polar bears are ordinarily timid animals, afraid of men, and afraid of wolves and dogs. But far from shore they have no enemy to fear. Besides their own kind they are familiar on the pack ice with only three living things—the seals on which they live, the white foxes which they unintentionally provide with food, but which never come near enough to be caught themselves, and the gulls which cry out loudly and flutter about them at their meals. When a bear sees men or dogs lying on the ice and moving a little, he apparently mistakes them for seals and is likely to stalk them and eventually pounce on them as if they were seals. (See also chapter 13.)

Occasionally bears will stalk a man who is upright. Stefansson once had a narrow escape when he himself was stalking a polar bear among some ice hummocks. He knew there was a bear in the vicinity and was searching for him in some rough ice when he heard a slight noise behind him and realized that the bear was stalking him, with only about 20 yards to go. There was just time to fire the decisive shot. The reason Stefansson had not seen the bear's approach was that it had not occurred to him to look back over his own trail; he was so used to hunting bears that the possibility of one of them assuming his own role and hunting him had been left out of consideration. A good hunter, like a good detective, should leave nothing out of consideration.

A 4-year-old polar bear will produce in meat the equivalent of four seals, and scarcity of ammunition may in emergency

make him the most economical source of food. However, bear meat has a fundamental defect. It has nothing to do with taste, toughness, or wholesomeness but lies in the stringy nature of the meat of any but the youngest. (See chapter 8.) Thus other meats are usually preferred when ammunition and other game animals are plentiful.

Polar bear skins are utilized for clothing to some extent. As discussed more fully in Chapter 9, the skins are strong but heavy, and not warm for the weight.

In utilizing whole bears in time of need the Stefansson parties scraped hair from the skin for fuel, and fed the skins to the dogs. It may be well not to eat bear livers or feed them to dogs, for some of them may be unwholesome.

Barren Ground Grizzly (*Ursus richardsoni Swainson*) is called by the western Eskimos *aklak,* by the Copper Eskimos *akshak.* The term "Barren Ground" is applied also to a number of other subspecies.

Formerly more widespread, these grizzlies are now said to be found in Canada, only in a restricted area from the Mackenzie eastward some distance beyond the Coppermine; in northern Alaska they do not appear to be very common on the north side of the Endicott Mountains, and seldom, if ever, come out on the coastal plains. In size they are medium compared with other grizzlies; color variable from yellowish to grizzly brown, with smooth foreclaws of medium length. Their diet is miscellaneous—largely vegetarian although sometimes including ground squirrels (spermophiles) and lemmings. Like all grizzlies they are shy and wary, seeking to be let alone by man, but dangerous if wounded and at bay.

Alaska Brown Bear, or Kodiak Bear. In many works of reference this is credited with being the largest carnivorous animal living in the world today. But, as said, other authorities would confer this honor upon the polar bear. A number of specimens have weighed from 1,200 to 1,500 pounds; the largest of record was 1,656 pounds. The color is relatively uniform, from light creamy brown to rich blackish brown, with little or no silver-tipping, and with short stout curved claws. These bears inhabit the islands and the Pacific coast of Alaska, from the Alaska Peninsula

nearly or quite to British Columbia. Their diet consists chiefly of grass, roots, and berries, but in addition they eat field mice. Along the beaches they may eat dead fish, whale, or seal that has been cast up on the shore.

Although provided with a fighting equipment second to none on the continent, these, like their Arctic land cousins, try to live peacefully and inoffensively. Like other grizzlies, whenever they discover the sign of a human being, whether they see or smell his footprints, or see him or get his wind, they immediately use every means in their power to get out of the way.

Almost as tame as shooting musk oxen is shooting grizzly bears. They are dull of sight and not very quick of hearing, and once a hunter sees them there is small chance for the bear. A wounded grizzly, however, is a difficult beast to deal with. They appear even more tenacious of life than polar bears. Natives warn you that if you must shoot them you should do so from a hill, for then a wounded bear has more difficulty charging.

The meat of both the Barren Ground and the Kodiak bear (or, indeed, of any bear) can be used to supplement the food supply. Likewise the skins can be utilized, if necessary, though, as with any bear skin, they are not warm for the weight. If circumstances warrant it, most hunters would prefer to keep the skin of a Kodiak bear, for instance, for a trophy. However, they make excellent bedding and are used by Eskimos as doors for houses.

SEALS

The order Pinnipedia to which seals, sea lions, and walrus belong, is large, with several families under which there are numerous subspecies. Although several of these species extend into the sub-Arctic and Arctic, we consider here only the ones which play a part in the instructions given in this Manual. If you should happen to be in a vicinity where members of a different species are found (for instance, the large *Phoca groenlandica,* which is numerous in the seas around Greenland), you would deal with them in the same fashion

and make use of their meat and skins in much the same way as you would those which we have described.

Erignathus barbatus; bearded seal; ugrug. Rare along the north coast of Alaska east of Point Barrow, although fairly common south and west of Point Barrow. Rare at Herschel Island, Baillie Islands, and Franklin Bay; numerous around Cape Lyons, abundant in Dolphin and Union Strait; in Asia, they range eastward from the Okhotsk Sea to the coast of Alaska; also found along the coasts of southern Greenland and of Iceland. Average weight 500 to 600 pounds.

Phoca hispida; hair seal—this classification includes several sub-species. Distributed throughout entire Arctic regions; they are found along coasts of Greenland and Labrador; fairly common everywhere along the coast from Bering Sea east to Coronation Gulf; along coasts of the Soviet Arctic, and are particularly numerous in the Barents and Kara Seas; they are also found in the polar sea at all distances from land and have been sighted in the vicinity of the North Pole. Average weight 125 to 175 pounds. Dr. R. M. Anderson reports a very large male shot at Cape Parry, December 12, 1910, measured 65 inches in length and greatest girth 54 inches, weight about 200 pounds.

Callorhinus alascanus; Alaska fur seal. Occurrence of the species in the Arctic Ocean is only casual. It is included in this list because we have suggested the possible use of its skin as a substitute for the skin of the hair seal or of caribou for Eskimo-type clothing.

Phoca hispida (called by Eskimos *natsik*) and *Erignathus barbatus* (called by Eskimos *ugrug*) are, then the seals that are likely to be of chief importance to the users of this Manual, the seals on which so many of the methods outlined hereafter are based. Where we speak of "seals," "seal skin," etc., throughout this volume, it is always the small hair seal that is meant; the bearded seal, or ugrug, which has its particular excellences, is specified as such.

HOW TO RECOGNIZE SIGNS OF SEALS

A man inexperienced in woodcraft may walk through a forest without seeing any sign of moose when signs will be patent to the hunter or guide who knows the woods and the

ways of animals. So a man who does not realize the presence of seals unless he sees their heads bobbing about in the water of an open lead might make a long journey over the polar ice and still retain his original conviction that food animals are absent. There may be on the sea ice inconspicuous signs of seals, as clear in their meaning when once noted as bear tracks in snow. How to recognize these signs is described below (in chapter 13 we tell of hunting methods).

The presence or absence of seals has nothing to do with latitude, as such, but mainly with the mobility of the ice. In any region where we have violent ice movement and consequently much open water, we have a large number of seals. Food they can find everywhere, but in certain places they lack easy opportunity for coming up to breathe.

During the summer seals congregate in regions of open water, deserting those where the ice lies but slightly broken. Then in the autumn, when young ice forms, they make for themselves breathing holes which they use all winter. If this young ice remains stationary, the seal remains stationary with it. If it floats in any direction he travels along, for his life depends upon his never going far from his breathing hole as long as the ice around it remains unbroken. If it does break and if leads are formed, he may do a certain amount of winter traveling along them, but this traveling ceases when the first hard frost forms new ice over the new leads.

AREAS FROM WHICH SEALS ARE ABSENT

From the point of view of seal life, there are in the polar mediterranean certain desert areas, as described *ante*. We repeat here: These desert areas are caused by the sluggishness or absence of currents, as deserts on land are caused by lack of rainfall and porousness of soil. And just as land deserts are restricted in area, so are the sea deserts. The experienced overland traveler crossing a new continent would know, or at least suspect, when he was entering a desert. It would then be a matter of judgment whether he was to turn back and give up his journey or whether he should attempt skirting the desert or making a dash across it. So it is when the ice traveler who depends on game for subsistence comes to one of these sea deserts. The signs are in the thickness

and evident age of the ice, in the fewness of the leads and of other signs of motion, and in the absence or rarity of seal traces on such patches of young ice as may be visible.

The younger the seal the more delectable the meat. Its lean and fat make together a diet upon which whole groups of Eskimos live in good health to a normal old age. Some whites do not like the meat at first, because it differs considerably from any meat with which they are familiar; but you gradually get to like it, and the longer you live on it the better you like it. You may be dreadfully tired of seal after three weeks, or even three months, but few are tired of it after three years. It is a complete diet—contains more than enough of all the vitamins, as well as calcium, iron, etc.

In addition to giving lean and fat for food, the seal furnishes fat for fuel. Many thousands of Eskimos have no other fuel in winter, and it does them very well. They burn the fat in stone lamps that, when properly tended, do not smoke or smell.

Besides food and fuel, the seal furnishes clothing. The Eskimos use water boots in summer that are made entirely of seal skin (uppers from one species, soles from another). In winter they use caribou skin boots which in some cases have sealskin soles. Raincoats are made of sealskin and so are mittens intended to be used in handling fish nets or anything that is wet. Coats and trousers for winter may be made of sealskin but this is seldom done except when caribou is scarce. (For description of sealskin garments see chapter 9.)

Sealskins furnish material for boats. The small seals are used for kayaks and the big (bearded) seals for umiaks—see chapter 12.

When a seal has been skinned by the method described in chapter 13, the resulting bag makes the *pok* which is used for a seal-oil container and which will hold the fat of about four seals. The same sort of bag may also be inflated by blowing and then forms a float with a buoyancy of two or three hundred pounds. Occasionally, instead of using canvas to convert a sledge into a boat, you might fasten three or four of these inflated poks to the sides of the sledge, making a sort of life raft. This Eskimo method is satisfactory

in warm weather; but not in winter, because the water which splashes over the sledge turns into an ice coating difficult to remove.

The *Encyclopaedia Britannica* says of the walrus (*Odobaenus rosmarus*) that it is a "large marine mammal allied to the seals. Characterized by the prolongation, in both sexes, of the upper canine teeth into tusks, which may reach a length of 2 feet, the adult walrus measures some 10 or 11 feet and is a heavy-built animal. * * *

"The walrus inhabits the northern circumpolar region in small herds. It prefers the coastal portion or ice-floes and feeds largely on bivalve molluscs which it digs up from the bottom of the sea with its tusks. Normally inoffensive and affectionate, when attacked the walrus can use its tusks with terrible effect, and the herd usually combine against an enemy. * * * The Pacific walrus, with longer and more slender tusks, has been separated as *O. obesus*. Like the Atlantic form, its numbers have been much reduced within recent years. * * *"

The reduction in numbers is notable around the Svalbard archipelago, where walrus, formerly plentiful, are now rarely seen. Between Greenland and the Canadian islands the reduction, though considerable, is not so pronounced. Comparatively, there has been little reduction, although noticeable, in Bering Sea and north of it. Northeastward from Bering Strait the walrus does not go in any numbers around Point Barrow, for it, unlike the seal, is unable to gnaw breathing holes in the ice, and therefore must keep out of waters where ice fields are extensive and little broken. For the same reason the walrus does not go in any considerable numbers west of Cape Schmidt (formerly North Cape) and Wrangel Island.

Walrus hide is sometimes used for covering the large Eskimo boat, the umiak, but is not considered as good as either the bearded seal or white whale, though more convenient than the bearded seal in that it is larger so that fewer skins are required for a single boat—perhaps three or four walrus hides for a 40-foot boat against six to nine bearded sealskins. Walrus is used also for boot soles, but seldom unless the hide has been employed for at least a year as a umiak cover;

otherwise it stretches unevenly and the boot goes out of shape. Walrus hides are used extensively for the cover of depots to keep the rain out and under some circumstances for roofs of houses. They are used for floor coverings beneath bedding.

At present the ivory from the tusks has some commercial value. Formerly it was used for harpoon points and other parts of harpoons, and sometimes in the construction of arrows and spears. It was used for bag and other handles and carved into toys. This carving has lately been developed along commercial lines. Eskimo carvings of various sorts are sold to tourists who visit Alaska and also by curio dealers in Seattle and other Pacific coast cities.

The first known commerce between Europe and North America, during the four centuries before Columbus, dealt partly in walrus ivory and walrus "ropes." These ropes were favored in Europe all the way to the Mediterranean. It is still an important use of the hide to convert it into a thong perhaps a quarter of an inch wide. This is done in one of two ways: You skin the animal, dry the skin, wet it again, make a hole near the center of the hide and cut round and round till the margins are reached. Another way is to make the thong when you skin the animal, or else to skin it by the casing method, in either event cutting round and round the body, spirally.

As in many other things, the competitors with walrus thong are from the hides of the white whale and the bearded seal, if a stout "rope" is required. When more slender and less strong ones are needed as, for instance, snow shoe babiche, it will be cut from the small variety of seal or from land animals, such as the caribou.

ALASKA GAME LAWS

The killing of all walrus in the territory of Alaska, except by natives for food or clothing, by miners and explorers in need of food, or for scientific specimens to be taken under permit issued by the Secretary of Commerce, is prohibited.

Walrus are likely to play a small part in the kind of economy outlined in this Manual. However, the meat is palatable and, as said, the skins are strong and useful. See chapters 9 and 12.

The idea that walrus meat, as such, is "strong" derives mainly from a reason applicable both to walrus and whales. These are very large warm-blooded animals, difficult to cut up in the place where killed. The towing ashore may take from one to several hours. If a steer were not cut up until several hours after being killed the meat would taste strong; but, knowing beef, we would realize that the fault was in the handling, not in the meat itself. However, white men, unfamiliar with walrus and whale meat, sometimes attribute to the animals themselves the strong taste which comes, as indicated, from a long decomposition period that has intervened between the killing and the cutting up.

WHALES

Of the many species of whales, we list the ones common to Arctic waters.

Of the Greenland whale, *Balaena mysticetus,* the *Encyclopaedia Britannica* says: "Head enormous, one-third the total length; rostrum greatly arched, providing room for exceptionally long baleen, up to 15 feet. Arctic, circumpolar, and formerly abundant off Spitsbergen, both sides of Greenland and the North Pacific to Beaufort sea, but reduced by whaling to the verge of extinction." This is one of the largest of sea mammals, reaching a length of from 50 to 60 feet. American whalers call it the Bowhead.

The waters around Spitsbergen are a good illustration of the above-mentioned reduction of numbers. According to Scoresby, no fewer than 57,500 Greenland whales were killed in this region between 1669 and 1775. During the same period reckless extermination of seals also took place. Now the Greenland whale has practically disappeared in the vicinity of the Svalbard archipelago in consequence of the havoc made by the early whalers.

American whaling north of Bering Strait was what it was called, "Yankee" whaling; if by Yankee we mean New Englander. On account of laws considered unfavorable, some of the vessels sailed at different times under the flags of Hawaii, when it was an independent country, of Chile, and of other nations; but most of the men and most of the money were from New England chiefly—rather from New Bedford than

from Nantucket, for Nantucket featured sperm whaling, which was non-Arctic.

Whaling north of Bering Strait, although not east of Barrow nor west of Wrangel, had considerable proportions before the War between the States. What is said to have been the last action of that struggle was a Confederate attack upon the northern (Arctic Alaska) whaling fleet, with a heavy loss of ships and cargoes, though not of men.

The industry spread east beyond Barrow definitely when there was a first wintering of an American whaler at Herschel Island, just west of the Mackenzie delta, in 1889. Ten to fifteen ships sometimes wintered at Herschel Island; occasionally more than 500 but never a thousand men. Other wintering places were farther east, chiefly the Baillie Islands off Cape Bathurst and Langton Bay in the southeast corner of Franklin Bay. The voyages were typically for three years.

The maximum catch per voyage was probably between 60 and 70 whales. Only the "bone" (baleen) was taken, with enough flesh of one or two whales to give the crew fresh meat, and to feed Eskimos who were employed as well as dogs belonging to whalers and to Eskimos. Bone ran a maximum of a little over 2,000 pounds per whale, with the average probably around 1,000 pounds. A high price for bone, although not the highest, was $4.50 the pound. At that rate a big whale would bring $9,000. In conversation one hears of "a ten-thousand-dollar whale."

According to information gathered at Herschel Island in 1908–12 by Dr. R. M. Anderson, the largest catches of the entire history of Yankee whaling east of Barrow were 69 whales by Captain Smith, steamer *Narwhal*, 1893–95; 67 whales by Captain Norwood, steamer *Balaena*, 1893–95; 64 by Captain Bodfish, steamer *Beluga*, also 1893–95.

Commercial whaling ceased abruptly about 1906, for three reasons which came along nearly together. Women's corsets ceased being fashionable; buggy whips ceased being used; a substitute was invented, called featherbone. In 1 or 2 years the price of whalebone dropped to 40 cents and even 20 cents a pound; practically there was no market.

In Arctic waters the industry has never been revived as oil whaling; oil whaling developments, tremendous in their way, have been in the Antarctic.

In prehistoric times the taking of the bowhead by primitive hunters seems to have been extensive, for signs of whaling are found at various points on the north coast of the Old World. In the New World whaling was carried on as far northeast as Cape Kellett, Banks Island, and perhaps nearly 200 miles east of Cape Parry on the mainland. In historic times, however, there has been no native whaling from Banks Island nor from farther east than Cape Bathurst on the mainland side. After the coming of the American whaling fleet, natives did not compete with the Yankees farther east than Point Barrow. They did give effective competition from Barrow to Bering Strait, the chief centers being Cape Smythe village, now Barrow Post Office, and Point Hope.

Natives and resident whites still like to take a few whales each year, both for human food and for dog feed, but this now only on the coast from Barrow to Hope.

A small whale, which may be a different species or a young bowhead, was favored as a food animal, not because it was easier to handle but because the meat was considered to taste better. This whale is a scientific problem as yet, and is, therefore known only by its Eskimo name, *ingutok* or *inyutok*. The usual Eskimo and local white view is that they are a small species. Some believe, however, that they are yearling and 2-year-old bowheads.

White whale or beluga, *Delphinapterus leucas,* kilaluak: Adult milk-white all over, young dark slate color, becoming gradually paler for several years until it attains its growth. While it is said at times to attain a length of 20 feet, its ordinary length is nearer 10 or 12 feet. The white whale is a circumpolar species, limited to the extreme northern coasts of the Old and New Worlds. Plentiful along the coast of Alaska, especially in Bering Sea and the Arctic Ocean, it also ascends the Yukon for a long distance. It is found along the Atlantic coast south to the St. Lawrence River.

In the Alaskan and west Canadian Arctic the white whale was as important as the seal, although not farther east than

Cape Bathurst. They came in schools during early summer. Unlike the bowhead, which was hunted from umiaks, the white whales were pursued and harpooned from kayaks. With a bowhead whale two or three inflated seal skins, each with a buoyancy of 200 or 300 pounds, were attached to each harpoon; and the thing was to follow the whale and get more and more harpoons into him, until it took so much exertion for him to dive and submerge all the floats that he was worn out, whereupon he was dispatched with a lance. The white whales, walrus-size or smaller, required only one harpoon and a single float. Indeed, they were sometimes killed outright with spears. In recent years they have been shot with rifles, but they usually or always sink. Therefore they must be harpooned at the same time as they are shot, so that the rifle is no great advantage. The vulnerable point for rifle shooting is the brain, or the spine at the base of the brain, preferably the latter.

The great killings of the white whale were made by driving them into shoal waters. Scores of kayaks would paddle out to sea when the watchers from the land reported a school on its way. They would get outside the whales, form a line, and with a great shouting and splashing of paddles would advance abreast, shepherding the whales to a bay or other shoal place where they could be dispatched.

The meat and blubber were used as with seal or walrus. The hide was in some districts considered even better than the bearded seal for boot soles and umiak covers. The leather is said to be excellent for various commercial uses, as, for instance, belting.

Prior to 1936, whaling in Alaska waters was unrestricted. On May 1, 1936, an act was passed to give effect to the convention concluded at Geneva on September 24, 1931, and subsequently ratified by the United States and 25 other countries for the regulation of whaling.

The narwhal, *Monodon monoceros*: "Adult greyish-white, with leopard-like spots, sometimes whitish when old, young unspotted; teeth unlike those of any other animal, reduced * * * to a single upper pair. * * * Arctic, rarely reaching Britain. Large numbers of narwhals are

killed by the Esquimaux in certain parts of Greenland * * *." They are very rare in or absent from Canadian waters west of Baffin Bay, as from Alaskan and eastern Siberian seas.

It is likely to be chiefly by accident that the users of this Manual will have occasion to utilize whales. However, when one has been killed or if it is found dead on the beach, it is a source of a large supply of food and fuel.

As an alternative to cannibalism or death from hunger, whales that have lain dead on Arctic beaches as long as 4 years have been eaten. By that time, however, all the lean has decayed away; the blubber has largely dried out; what remains has become somewhat like felt in texture, and the interstices have been filled with products of the dashing surf and spray, among them salt and iodine. Stefansson and his party of a half dozen Eskimos, when without "solid" food for a few days, tried eating this sort of blubber. Some of them did eat it and kept it down, others found it worse than nothing because it made them ill.

A whale that has been on the beach only a year does not taste stronger than venison and game birds do that are fashionably eaten. Both lean and fat are at that stage nourishing and nonpoisonous.

The idea that people die of "ptomaine poisoning" from eating "rotten whale" has been checked by Stefansson in a half dozen cases where serious illness or death was reported. In only one of these cases was there a possible connection with decayed whale. All other deaths were from eating fresh whale. The most serious case, where several Eskimos died within a day or two, was from eating a white whale so fresh that the flesh was still warm when it was cut up and put in the cooking pots—the cooking was Eskimo-style, probably to what we call medium done. Whatever killed the people was, therefore, present in the flesh of the living or at least the still warm animal, and had nothing to do with any of the foodborne poisons which are ordinarily thought of as "ptomaines."

A stranded whale can be a source of great quantities of food indirectly. If a party is marooned, they can camp

at some distance from the whale and set armed watchers by the whale who shoot polar bears, foxes (and possibly a rare wolf) when they come in to feed on the carcass.

SECTION II

DOMESTIC ANIMALS

Reindeer is the same animal as caribou, only domestic. They vary in size by subspecies, as caribou do. About the smallest are certain Lapp varieties from Scandinavia; about the largest are from the Tungus section of Siberia.

All the original reindeer breeding stock of Alaska came from Siberia. Most of the imports were of a rather small variety from the northeast, the Chukchi peninsula; but there were also some Tungus deer. When export from Siberia was no longer permitted by Russia, some effort was made to increase the size of Alaska reindeer by crossing with caribou bulls of large variety secured from the Yukon valley.

Large herds of reindeer are found in Alaska (see below) and in Siberia from the Chukchi peninsula west to the Kolyma and beyond. They are also numerous in northwestern Siberia, northern Russia, and in Finnish, Swedish, and Norwegian Lapland. Herds have recently been introduced in Canada from Alaska by the Canadian Government.

True albinism, while not common among reindeer, does occur but seems to be unknown among caribou. Spotted and white deer, which are not true albinos, occur frequently in Alaskan herds but are seldom if ever found among caribou. This usually gives a ready way of detecting that item of movie faking which represents domestic reindeer as wild caribou. The character may be used safely in airplane or other scouting or census taking where it is necessary to discriminate between wild and domestic animals; for you would seldom have a reindeer band of any considerable size without one or more white and spotted animals, while you would not expect even one spotted or white among a thousand caribou. (Still, it must be remembered that reindeer sometimes stray and get mixed with caribou herds; you would have to make at least a mental allowance for this possibility.)

By the last decade of the nineteenth century the native

caribou of northwestern Alaska had been slaughtered to such an extent that it was feared by some the Eskimos would suffer from a food shortage. Through the efforts of a missionary, Dr. Sheldon Jackson, 1,280 reindeer were introduced into Alaska from Siberia for the purpose of building up a permanent food supply for the Eskimos. The introduction period was eleven years, 1892–1902.

From these small beginnings there grew up an extensive stock industry in Alaska, so that it was estimated in 1930 that there were in the Territory a total of 1,000,000 animals, some of these in herds owned by whites (individuals, corporations), others in Eskimo herds which were under the supervision of the United States Government.

Then there developed a controversy, which we do not go into here, centering largely on whether the reindeer industry should be permitted to operate as it had in the past (with some herds under white ownership and others native-owned) or whether it should be maintained and developed exclusively by and for the benefit of the natives. The problem was complicated by many factors, and there was no doubt considerable misunderstanding on both sides. Whatever the merits of the opposing viewpoints, there was the unfortunate result that during the period of uncertainty, about from 1928 to 1940, many herds were neglected—some animals running wild and mixing with the caribou, while many others, instead of being tended as formerly, were killed by the Eskimos without regard to need or economic value. With the herds untended, depredations by wolves were heavy. Now, however, as indicated below, the industry seems on the way to being stabilized through control by the Department of the Interior. It is hoped to develop a plan through which the deterioration process may be changed to one of increase.

By the Act of September 1, 1937, Seventy-fifth Congress, Public, No. 413, ownership of reindeer was vested exclusively in natives (Aleuts and Eskimos, chiefly), the United States Government to take over and pay for herds of non-native-owned deer.

During the period 1937–40, while negotiations were going on, estimates of the number of nonnative deer differed—the white owners claiming about 500,000, the Congressional Com-

mittee about 180,000. By 1940 everyone concerned agreed that there were considerably fewer deer than had been seen the summer 1938.

On June 24, 1940, the Secretary of the Interior reported that the reindeer-acquisition program had been completed. The number of reindeer purchased by the Government from white owners amounted to 82,538, with not more than 1,000 animals remaining which would have to be obtained by condemnation proceedings.

RANGE

The chief grazing areas for the formerly white-owned part of the reindeer industry, are, from north to south, on the Noatak River around Kotzebue; on the Kobuk River around Kobuk; on the Selawik and Buckland Rivers; throughout Seward Peninsula; on the Unalakleet River; on St. Michael's Island and the lower Yukon; on Nunivak Island; on the lower Kuskokwim, including Goodnews Bay; on the Nuskagak River; on the Wood River which flows into Nushagak Bay; on Alaska Peninsula in the Aleutian Range; on one Aleutian island, Umnak. A few native-owned herds also graze in the named areas. There are one or two on the Aleutian chain.

From this listing it appears that the largest and in some ways the best reindeer grazing section of Alaska was solely in the hands of natives—the vast triangular coastal plain that has a northern apex at Point Barrow and a southern base along the north slopes of the Brooks Range. South of that Range there is a little reindeer country, mainly in the slopes of the mountains; down lower, towards the Yukon River, the land is too forested. Along the Bering shore sea breezes do not keep the forest quite so effectively at bay as they do north of the Brooks Range so that prairie lands, the best reindeer pastures, are not as extensive eastward from this western sea as they are southward from the polar shores.

By our listing, above, it is seen that of the Bering mainland grazing the whites controlled about half, natives the other half. Of the two big islands of Bering Sea we have said Nunivak was under the white owners; this was balanced by St. Lawrence Island, exclusively native.

In December 1929 the Canadian Government purchased from the Lomen Reindeer Corporation in Alaska a herd of 3,197 reindeer, to furnish the nucleus for reindeer raising in the Dominion's northern territories. Then began the great reindeer drive, lasting 5 years, 3 months, until the band of deer was finally delivered in March, 1935, at the Mackenzie delta. During the period of the trek there were considerable losses from wolves and other causes, which were only partially offset by natural increase; the herd numbered 2,109 animals upon arrival at their Canadian range.

By the 1939 count the herd at the Mackenzie delta numbered 4,146. A band of 900 which was separated from the main herd and driven eastward in December 1938 has been established in the Anderson valley under native management; there was a satisfactory fawn crop, with the August 1939 round-up showing 1,196 animals.

The reindeer constitute an important source of food supply for civil or military populations in Alaska. They are equally important as a source of material for clothing. All that is said elsewhere in this Manual concerning the use of caribou for food and of caribou skins for clothing and other equipment applies equally to the meat and skins of reindeer.

Reindeer support themselves, whether winter or summer, on the vegetation of the Arctic prairies and can discover food here and there in any but the most densely forested areas. If their meat is needed for a large body of men, a herd of them could be driven on the hoof and butchered where most convenient. Winter butchering on snow is a clean process in cold countries. Once the carcass is frozen it can be handled like cordwood. Even if it gets muddy or dirty you can wash it off, for it is as hard as granite from the freezing.

The reindeer has further value as a draft animal, and is used extensively for this purpose among the reindeer-owning peoples of the Old World.

At present little use is made in Alaska of reindeer as draft animals, but there was a rather extensive utilization for several years around 1918. Reindeer are less expensive to use than dogs but it is more work to tend them, so that gradually the Eskimo reindeer owners shifted back to dog driving.

With the increase in the number of dogs came an increase in the amount of meat needed to feed them and a resulting slaughter of thousands of deer to provide dog feed. It is said, for instance, that during 1 year the people of a single Alaska village, Deering, killed more than 5,000 reindeer to feed their dogs. Thus we have another factor in the mentioned numerical decline of Alaska reindeer.

For a detailed discussion of the use of reindeer as pack and draft animals, see Section V, Chapter 12.

MUSK OXEN

Attempts to domesticate musk oxen have been made by the United States Government, in Alaska, by the Norwegian Government, in Spitsbergen, and by an Icelandic private company, in Iceland. The Soviet Government has announced its intention to make the experiment also.

The chief reasons for domestication are that musk oxen give meat like beef and wool like sheep. They need no barn to shelter them, no hay to feed them, or protection from enemies except humans (in Alaska also from grizzly bears). Apart from possible attack from micro-organisms, it would appear they would do well indefinitely far south, for they are long-lived in zoological gardens. But the central argument for their use is that they are capable of turning into food and clothing far northern vegetation which no other animal uses.

Reindeer, an ancient domestic animal, attempts to confine itself to lichens and browse in winter, although they eat grasses, sedges, etc., if they have to; in summer they prefer grass. There is estimated to be in the Arctic at least 10 times as much grass food as lichen food, so that when you have stocked those lands with as many reindeer as the lichens will support, 90 percent of the grass still remains to be used.

The Icelandic experiments have gone badly in that all the animals have caught diseases, no doubt from other domestic animals, and have died. The United States experiment appears in a fair way of success.

When a band of 34 musk oxen were brought by the United States Government from Greenland to Alaska some years ago

for experimental purposes, they were first kept in the vicinity of Fairbanks, where they had no difficulty with the climate and were found able to protect themselves from all enemies except the brown (Kodiak) bear. The bear depredations, however, were serious and in 1936 the herd (31 in all) was moved to Nunivak Island, where there are no bears. Here they have been thriving, increasing satisfactorily. In March 1940 the Nunivak herd numbered 70 animals.

Studies on the wool of this domesticated group made by the University of Alaska have confirmed the results attained by the University of Leeds on the wool of undomesticated animals. There have been like studies by or under the supervision of departments of the United States Government.

Several observers have said that you cannot tell the meat from beef by color, taste, or odor, and only by the shape of bones, if any are included in the piece you are eating—the musk ox bones being unusually stout in proportion to length. The milk has a taste similar to cow's milk and is in quantity per animal about three or four times that of reindeer milk, which latter is used in the Scandinavian countries for butter and cheese as well as for drinking purposes.

DOGS

Lieutenant Schwatka tells that he used to be annoyed by having people ask him constantly, "How big is an Eskimo dog?" He finally developed a bright, effective reply: "An Eskimo dog is about the size of a rock." On the Schwatka analogy, the answer to "What does an Eskimo dog look like" is in Pennsylvania that he is like a Pennsylvania dog, in Ohio that he is like an Ohio dog. For the usual come-back, "What, then, is an Eskimo dog?" The reply would be that it is any dog owned by an Eskimo.

These three replies cover the situation at least for the twentieth century. For the eighteenth they are probably not far astray. Eskimo dogs have long been mongrels; but it seems there may have been a time, before European influence reached America, when there was approximately a single breed. Judging by what is still fairly typical in the more isolated districts, these dogs were probably from 40 to 60

pounds in weight for males, well-furred, with rather sharp noses and tails well curled up on their backs. That they were of uniform color seems doubtful.

Certain common views of Eskimo dogs are vulnerable. The claim that they descend from the northern wolf is particularly fragile. For that wolf runs from 100 to 120 pounds or more, double the probable size of the Eskimo dog; the wolf drags his tail, and is of a uniform color pattern—darkest on the shoulders, lightening downward as well as back. The Eskimo dog, whatever his color may have been, was almost certainly not wolflike, since this color is rare now among dogs belonging to Esk mos and is usually found where it is known that the father or some not very remote ancestor was a wolf.

Saying that the Eskimo dog is not derived from wolves is, of course, very different from denying that there may have been now and then a wolf strain joining what was primarily a dog stock.

About the sole analogy that really holds between wolves and Eskimo dogs is that neither barks—both howl. Perhaps the wolf-dog idea started from this similarity.

From southern North America the European horse spread more rapidly than the Europeans themselves. Similarly the European dog outstripped his master across northern Canada and Alaska. These European forebears were of several breeds, for they came to America with explorers and colonists of practically every nationality from Spain and Italy to Norway and Russia. By the time their descendants reached widely separated parts of the American Arctic there had developed a wide variation in size and appearance. The difference would then be further accentuated by admixture with whatever may have been the original Eskimo dog. To illustrate:

A frequent query is regarding the difference between huskies and malamutes. For the answer, bear in mind what has been said about the mixture of the hypothetical original Eskimo dog with European and perhaps Asiatic stocks. The rest of the explanation is linguistic.

The Hudson's Bay Company's servants used to speak of the Eskimos as Huskies. A husky dog is, therefore, an Eskimo dog. This designation spread from northeastern North America, where the Hudson's Bay Company is strong.

When the gold rush reached Bering Sea the stampeders found near the mouth of the Yukon a group of Eskimos called Malligmiut, meaning "the people of the place where the waves are high," which no doubt signified that these people had lived or were living near some flats where breakers roar in from an open sea. The dogs purchased from them were naturally Malligmiut dogs. In the careless pronunciation and spelling of the miners this became Malamute.

There have been people in northeastern North America whose minds saw clearly the picture of an Eskimo dog which they, following the Hudson's Bay Company, called husky. Similar clarity of mental vision developed the malamute idea in western Alaska. But naturally the dogs in northeastern America and western Alaska were not the product of exactly the same mixtures. On the law of chances they were bound to differ.

When dog breeders go to work, each selecting for survival those traits which fit his picture, there will develop among the followers of the husky conception one type and among the followers of the malamute conception another type. Eventually these will become "pure breeds"—perhaps they are "pure" by now.

Naturally certain dog types, if mixed with the hypothetical Eskimo stock, would disappear by selection. A greyhound admixture would so disappear, for they could not stand the climate and would freeze or would be killed by their owners because useless.

Being ordinarily a small, well-furred mongrel, the "Eskimo dog" gives good results for heavy work when crossed with mastiffs. There have been crosses with Newfoundland, but these do not seem quite so good. The mastiff, pure, has two chief draw-backs—his fur is not good enough nor are his feet. The Newfoundland dog may do for fur but his feet are not good. Half-breeds from both, with the Eskimo mongrel, usually have both good fur and sound feet.

Perhaps the best cross, whether with bigger or smaller dogs, is the wolf. There appears to be no reason to think that the product is undesirable temperamentally. Testimony that they are vicious probably comes, in most cases, from people who, knowing there was a wolf strain, were afraid of the

pups and brought them up accordingly. Stefansson testifies that he had two dogs known to be half wolf and that in temperament and all other qualities they were about the finest he ever had. They were particularly gentle and gave minimum trouble in fighting with other dogs, although they were powerful and in a fight nearly or quite always victorious. He does not exactly credit the gentleness to the wolf blood. The temperament of these dogs was probably in large part the result of their having been brought up as well-treated house dogs.

Though not so strongly of the opinion now, Stefansson expressed in *The Friendly Arctic* the view that the white man's dog, of whatever kind, seems to have more "character" than the Eskimo mongrel. The latter (he then felt) will stop pulling when he gets tired but the white man's dog seems to have a sense of duty and, especially when he is well treated, will continue working hard though his stomach be empty and his legs tired. This view may have geen a generalization on the basis of too few observations but is at least worth considering.

For a discussion of the care of dogs, methods of harnessing, etc., see Chapter 12.

SECTION III

FISH

On a number of sub-Arctic rivers, particularly in Alaska, the run of salmon and other fish gives the main food supply of the year to natives and could do so to whites if they were willing to live on them. For it has been established that a diet consisting exclusively of fish and water is quite as healthful as a diet exclusively of mammal flesh and water. In both cases you avoid every kind of deficiency disease and maintain good general health, whether in hot weather or cold. (See Section II, Chapter 8, and Section I, Chapter 10.)

However, in Alaska it will only be in emergencies that white men depend mainly on fish. So a discussion does not appear called for beyond what we have under fishing methods in Chapter 13.

On the Arctic mainland coast of North America and Asia

fishing is less cultivated by the natives, but that does not always mean that fish are less numerous. It may mean instead that the people have never developed a fish culture or that other supplies of food are more easily obtained and better liked—as walrus, seals, caribou.

White men have found both on the Alaska and Canadian Arctic coasts that when they are told by natives that certain localities are good for fish, the information is usually correct; but when they are told that certain localities have no fish, there is little correspondence between the information and the fact. For instance, Stefansson camped once for several weeks at the mouth of the Ikpikpuk River in Smith Bay, eastward from Barrow, and never put out nets or made other attempt to fish because the natives with whom he was said they knew there were no fish. Just as the party was about to move—had to move for other reasons—they discovered that this was an excellent fishing locality. Usually it is worth while to shove a net out from the beach wherever you happen to be, in the manner described in Chapter 13.

The fish caught in nets near shore are usually small, of the white-fish type, locally known as herring, or perhaps salmon trout. There are known to be cod in the Beaufort Sea and east as far as Cape Parry. Only a few have been caught, but those in nets pushed out from the beach. The habits of the cod are such as rarely to bring him inshore, so that a few having been secured may indicate a great wealth outside.

As an indication of what may be expected on Arctic coasts and in the lower reaches of rivers that flow into the Arctic, we give a synopsis of notes on fish and fishing made on the second Stefansson expedition, 1908–12, by its second in command, Dr. R. M. Anderson, now biologist of the National Museum, Ottawa.

Catostomus catostomus (Forster). Long-nosed Sucker. Milluiak—name given by Eskimos of northern Alaska and the Mackenzie delta. Miluk—milk; milluiak—he milks, or sucks.

Found commonly in parts of the Mackenzie delta; not valued very highly as a food fish by the Eskimos, and used only for dog food when other fish are obtainable.

Argyrosomus tullibee (Richardson). Tullibee. Toolaby. It is probably the species known to the Mackenzie Eskimos as pikoktok.

This fish is taken commonly in branches of the east side of Mackenzie delta; large numbers were caught in nets set under the ice of a large lake south of Langton Bay. It resembles somewhat another fish called the Anarkhlirk. The Anarkhlirk is much more highly regarded by the Eskimos than is the pikoktok, because the former species is usually fatter. The pikoktok is usually without much fat, and the flesh is rather coarse and tasteless.

Leucichthys lucidus (Richardson). Great Bear Lake Herring. Kaktak (pl. Kaktat), the name given by all Eskimos from northern Alaska east to Cape Bathurst.

The most common food fish, found almost everywhere along the coast, and for some distance up into the larger rivers. Anderson found the species common as far east as Coronation Gulf. It is generally taken in gill-nets, during the whole summer, but in early spring at the time when the ice-sea opens up into cracks (early in June, and later), large numbers are caught with hooks through holes or cracks, or from the edge of floating or grounded ice-cakes near shore. This fish is the species commonly spoken of as "whitefish" by white men and English-speaking natives along the Arctic coast.

Clupea pallasii Cuvier and Valenciennes. California Herring.

Great numbers come into the Cape Bathurst sandspit during the latter part of August. Only occasional stragglers appear during the middle of the month. On August 3d, 1911, one end of a 200-foot sweep-net was run out from the beach with a dory, and drew in about 13 barrels of Herring (about 3,000 fish) at one sweep. A very few *Leucichthys lucidus* were taken in this haul. Three days later, at the same place, two hauls brought in about a barrel and a half of Herring and about two barrels of "Whitefish." The Herring were very fat, one Herring being as satisfying as two much larger "Whitefish." The Baillie Islands Eskimos say that the Herring were never caught here before the white men came (a little

over 20 years ago), and think that the Herring followed the white men in. The explanation seems to be that the Herring schools came in only periodically, and not often close inshore, while the Eskimos did not use long seines, confining their fishing operations to short gill-nets along the beach.

Stenodus mackenzii (Richardson). Inconnu. Connie. Asjhiurok, commonly called Shi (shee) by Mackenzie River Eskimos.

Common in the Mackenzie River, Great Slave Lake, and up the Slave River as far as the Grand Rapids at Fort Smith, 60° N. Lat. Found in brackish and salt water as far west as Herschel Island, on the east side of the delta, to Toker Point.

Large numbers are caught in gill-nets in brackish water at Shingle Point, Mackenzie Bay, in July and August, but the flesh is rather soft and flabby at that season. Eskimos catch many with barbless hooks through the ice on the east mainland side of Richard Island in October, November, and December. The Connies are fat and firm of flesh at that season. Not many are caught in midwinter, but they bite better again after the sun comes back, later in the winter. The average weight here is 8 or 10 pounds, but a specimen taken at Fort McPherson, Peel River, weighed nearly 50 pounds.

Salvelinus malma (Walbaum). Salmon Trout. Ekkalukpik, name given by Eskimos from northern Alaska to Coronation Gulf.

Found in most of the larger streams where the water is clear. Not so common in salt water, but quite frequently taken at Herschel Island, Cape Bathurst, and Langton Bay. While seining some pools in the Hula-hula River, in the foothills of the Endicott Mountains, Alaska, together with the common form, the party caught a large number of what may be a dark phase of this variable species, or perhaps another species. The common form seen near the coast has back, dull grayish green; sides, pale silvery green, with numerous round, pale pink spots; and belly, silvery white. The others had back, very dark olive, almost black, with very faint, small, obscure, pinkish spots, some irregular, some comma-shaped, etc.; sides, bright olive-green, with brilliant vermilion spots; belly, bright vermilion, sometimes inclined to crimson, slightly

paler along median line, and fading to salmon color on breast and throat; pectoral and ventral fins with anterior border white. Females were duller colored, belly pink or rosy, sometimes with a yellowish tint, and the lower jaws were less strongly hooked; most of the fish were spawning at that time (September 11, 1908), the large yellow eggs being about the size of No. 1 shot. These brilliantly colored Trout were seen only in the Hula-hula River.

Cristivomer namavcush (Walbaum). Lake Trout. Kaluakpuk, Mackenzie River Eskimo name for fish brought from the Eskimo Lakes. Also called Sinayoriak by Mackenzie River and Baillie Islands people. Ishiumut, Coronation Gulf Eskimo name.

Found in most large inland lakes from Alaska to Coronation Gulf. At Great Bear Lake the people claim that they are often taken of 40 pounds' weight, and occasionally run to 60 pounds. They are taken on set-hooks, or by "jigging" through the ice, or in nets.

Thymallus signifer (Richardson). Arctic Grayling. Sulukpaurak (Alaskan Eskimo), or Sulukpauyak (Mackenzie River Eskimo).

The Grayling was observed in the Hula-hula and Chandlar rivers, Alaska, in the Horton River and its tributaries, and in the Dease River. It was not observed in the delta of the Mackenzie River, as the water seems to be too turbid, but several were seen in the Mackenzie at Fort Providence, where the river water is quite clear. The Grayling is commonly called Bluefish on the Mackenzie.

Usmereus dentex Steindachner. Arctic Smelt. Very rarely taken along the Arctic coast.

Esox lucius Linnaeus. Pike. Jackfish. Shiulik, name given by Eskimos from northern Alaska to Cape Bathurst. Found abundantly in the Mackenzie delta and other rivers, also in lakes as far east as Coronation Gulf.

Platichthys stellatus (Pallas). Starry Flounder. Small Flounders were occasionally taken in nets at Langton Bay only; they did not appear to be very common.

Microgadus proximus (Girard). Tomcod. Ogak (pl. Okat), by Eskimos as far east as Coronation Gulf.

At Toker Point, on the east side of the mouth of the Mackenzie River, the species is apparently rare. Locally, common in Liverpool Bay. Tomcod are very abundant in certain spots near the eastern end of Langton Bay, and very easily hooked through the ice all winter with almost any kind of hook. In Coronation Gulf they are common in certain localities. The Copper Eskimos catch them with a very large, barbless, gafflike hook which is "jigged" up and down. On the shank of the hook, 2 or 3 inches above the point, small bangles of white bone are suspended. When the fish come to nibble at these swinging bangles, the hook is jerked sharply up, usually catching the fish in the throat. A species of Rock Cod, growing to 18 inches in length, is occasionally caught in the Tomcod fishing place at Langton Bay, and is called Ugavik. The Rock Cod was not observed elsewhere.

Oncocottus hexacornis (Richardson). Six-horned Bullhead. Kanaiyuk is the Eskimo name for the Sculpin from northern Alaska to Coronation Gulf.

This Sculpin was described from specimens collected at the mouth of Tree River near the Coppermine. Sculpins or Bullheads are found almost everywhere along the Arctic coast, but are only occasionally eaten by the Eskimos, at times when other fish are scarce. They are quite common as far up the Mackenzie delta as Kittigaryuit. They are frequently taken on hooks while fishing in salt water for Tomcod and other fish. The common, universally distributed species is dull drab-colored, paler below. In Langton Bay there is another species, averaging a little larger, and lighter colored, mottled with yellowish.

Lota Maculosa (Le Soeur). Ling. Loche. Known as Titallirk by the Eskimos from northern Alaska to Cape Bathurst.

It is probably the favorite food fish of all these Eskimos, and is universally distributed in fresh and brackish waters, but seems nowhere to be taken in very large numbers. The very large, fatty liver is considered the best portion for food. It is caught both in gill nets and on set hooks on the bottom.

SECTION IV

INSECTS; PARASITES AND PESTS

In comparison with temperate zones and tropics the Arctic has few species of insects but some of these in great numbers. It is the general belief that most of them survive the winter as eggs that hatch in spring, but some at least derive from hibernation, of which we give some account. We quote, paraphrase, and condense from Frits Johansen, who was entomologist of the third Stefansson expedition, when he had an opportunity for study in Arctic Alaska and in Arctic mainland Canada as far east as the Coppermine district. He had previously worked upon the insects of the northern east coast of Greenland. We quote from his Insect Life on the West Coast of America, Ottawa, 1921:

"Insects are scarce along the Alaskan Arctic coast after October and are found only under stones and driftwood, or by digging in the frozen tundra or cutting holes in the fresh-water ice * * *.

"The main objective of the hibernating insects is to find, before the snow and frost come, some place where the spring water can best be avoided. They therefore take every advantage of cover, especially of those places likely to become free of snow in the early spring. In this, not all are successful, but they are more likely to be found, during the winter, on such exposed localities than on lower ones that have a better vegetation. An exception is, however, formed by certain larvae, such as large diptera, e. g., tipulidae, which hibernate down in the ground until the medium surrounding them thaws. Aquatic insects and larvae that inhabit water all through the year endeavour to bore themselves into the mud and, failing this, are killed, and hibernate only as eggs when the water freezes to the bottom.

"* * * Most hibernating insects can withstand temperatures down to 50° below, and the mortality may be ascribed rather to factors in the life-cycle of each particular insect than to the cold.

"In the fresh waters of northern Alaska insects and larvae are abundant, even in winter, as compared with those on

land. * * * In a pond only 4 feet deep, on which the ice was 10 inches thick on October 9, many copepods, *Limnocalanus johanseni* Marsh, ostracods, and other minute animals, and a number of midge larvae were found. Ponds such as this would, of course, freeze to the bottom later in the winter."

Among the organisms which Johansen concluded were hibernating successfully in lakes that froze to the bottom were: Aquatic diptera—larvae (especially tipulids and muscids); dytiscid—beetles; trichoptera—larvae and perlid larvae; mosquitoes—females, a few (*Aëdes* sp.); various midge larvae; and hydrachnid mites.

Johansen concludes that various insects pass the winter at various stages of development. He lists them as: imago, larva, nymphs, and pupa. Bees and wasps may hibernate as queens.

We shall dwell mainly upon those insects that affect human life conspicuously in the Arctic, whether directly or indirectly, and have no more than a brief sketch of the rest.

One insect in flight has been reported farther north than any land in the world; for Peary saw a bumblebee about a half a mile north from the north coast of Greenland when he was returning to it in spring from a sledge journey by which he had attempted to reach the North Pole. A butterfly was reported by the De Long expedition fluttering over the sea ice in spring some 20 miles from the nearest tiny island, several hundred miles north from the mainland coast of Siberia, and nearly a thousand miles north of the Arctic Circle. This insect was captured, sent to the Smithsonian Institution and receipted for; but was then lost. There has been much search for it, including that by a European entomologist who came to America a few years ago on purpose. The mystery apparently cannot be solved. However, the Soviet Government now has a scientific station on the De Long Islands. Perhaps they have already captured butterflies there, some of which would probably be of the same kind as De Long's capture.

Among the insects which are not pests and which are found in the most northerly islands in the world are, besides the two mentioned, house flies and beetles. There is a considerable number of other insects.

LICE

It is generally considered that there are two main kinds of human lice, those of the head and those of the body. In many Eskimo communities there are lice; but the communities vary conspicuously, which is known to the Eskimos and often reported to great distances. For instance, it is commonly said throughout Alaska that the lousiest natives are in the delta of the Yukon, the fish eaters.

Apparently there were some communities from which all human lice were completely absent. Amundsen reports for King William Island that in 2 years they found only one lousy individual and this (strangely, says Amundsen) was an old woman who had been employed as seamstress on his ship.

Generally speaking, then, you are in some danger of getting lice when traveling through Eskimo communities, though certainly not in more danger than if you were doing social work in a big American city.

Apart from methods of handling lice which readily occur to anyone, since they are more or less traditional with us, there are some special suggestions for the Arctic.

Freezing probably does not kill even the grown lice. It certainly does not kill the nit. What you do, then, is to hang up an infested garment for an hour in the cold, till the live lice are numb; then you beat it like a carpet and the lice fall out. Now wear the garment long enough for some of the nits to develop into lice, and repeat the freezing and beating. In this way lice may be completely eliminated from a garment in a few days.

FLEAS

There are apparently no fleas in the Arctic. None have been found on foxes or wolves, and if there are any in your party they probably came in with your own men or dogs. Fleas are seldom or never a problem in northern work.

Mosquitoes and sandflies are more of a problem, so far as numbers are concerned, in the Arctic than in the tropics. There probably are 10 times as many mosquitoes per square mile over at least two-thirds of the land north of the tree line as the highest average anywhere attained for even a

small area in the tropics. However, these northern pests do not kill unless by actually sucking blood. Perhaps there is a small degree of direct poisoning as well; but still you have the main consolation that they do not infect the victim with disease, certainly not with malaria or yellow fever.

MOSQUITOES

It is estimated that the number of species of mosquitoes in Arctic and sub-Arctic regions approaches 30; of these 4 or 5 are decidedly important in Alaska and northern Canada. The principal ones are *Aedes punctor, A. communis, A. aldrichi,* and *A. stimulans*. Practically all of the species which are pestiferous and annoying pass the winter in the egg stage.

The mosquito season starts early. Stefansson reports for the north shore of Great Bear Lake, which is about under the Arctic Circle, that the first mosquitoes appeared the first week in May (1911). Throughout the Arctic the most severe annoyance is usually experienced from about the middle of June to the middle of July, although some of the mosquitoes persist through the summer until the heavy frosts of the fall—which, in the Bear Lake woods may be any time in September.

The chief reason why mosquitoes are worse in the Arctic than anywhere else appears to be the slight variation in heat between midnight and midday, giving, when the warm weather sets in, ideal incubation conditions.

These special conditions of Arctic summer temperature produce on insects an effect that has startled travelers. In temperate zone districts, such as the Adirondacks, the young of the mosquito are likely to be killed by a night chill, for the long hours of darkness permit a great drop in temperature as compared with the noonday. The Arctic mosquito has, on the contrary, at birth and during early life a suitable temperature both at midnight and at midday. This decreases the infant mortality to a minimum and accounts for the clouds of mosquitoes which make the summer wretched.

The second reason why the North is a mosquito paradise will be the incredible number of tiny lakes. Wherever a deer or other beast has trod is a little puddle or hole, ideal for the

growing mosquito. The roughness of the ground forms other puddles. The water remains in these because of the permanent ground frost a few inches or a foot or two down, far enough away not to chill materially the water in which the mosquitoes are hatching and growing, near enough so the water cannot percolate down to leave the young mosquito high and dry.

If night chills are the greatest cause of infant mortality among mosquitoes in the temperate zone, desiccation is perhaps next. From desiccation also they are safe in the Arctic.

Though perhaps not impossible, it is difficult to exaggerate by words the number of mosquitoes you find in suitable Arctic localities. Stefansson vouches for it that on numerous occasions he had to make repeated attempts before he could take sight on caribou with a rifle. He would brush the mosquitoes from front and rear sights; before he could get a bead there were insects on at least one of the sights and sometimes on both. Seton, speaking of mosquitoes north of Great Slave Lake, has said that they settle so thick on short-haired parts of animals that you cannot tell the color of the skin.

You are wholly free from mosquitoes only at sea. On the great northern lakes they may trouble you a little even far from land, but only in case your vessel leaves shore in a high wind which keeps the plague under cover and then gets a calm out in the lake so that they can leave their hiding places and begin flying around. Stefansson has reported thousands of mosquitoes on the sheltered side of a boat-sail far from shore. Traveling in the middle of one of the great northern rivers, such as the Yukon or Mackenzie, you are reasonably free; but you are attacked the moment your boat approaches the land.

In good-sized towns, such as Nome or Fairbanks, you have little trouble in among the houses. A fairly extensive area that is drained will also have few. On a shore you are not bothered when the wind is from seaward or lakeward; right on the Arctic shore, with a land wind, the mosquitoes bite you. Chilly winds from the sea have a certain dampening effect on mosquitoes for a few miles inland; but frequently mosquitoes are pretty bad within half a mile of the beach, even with a sea wind.

The mosquito is a great enemy to many northern animals.

Probably most of the birds are nearly or quite immune. Except for biting around the eyes, they don't bother materially musk oxen or grizzly bears, because of the thick fur; the polar bear is usually out of reach at sea during the fly season. They do annoy foxes and wolves. Dogs of Eskimo and white owners are frequently so bitten that there is a running sore around each eye, and perhaps other parts of the body where the hair is short. You can keep mosquitoes away from eye sores by an ointment, but only if all dogs are tied—loose dogs will lick almost any preparation from each other.

Caribou find the mosquitoes intolerable and dash about vainly trying to be rid of them. In a few places, such as among the rugged hills south of Coronation Gulf, snowdrifts persist in the shade well into the mosquito season; there you will find caribou lying on the snow, getting some protection.

Animals and men not used to mosquitoes swell with their bites. Stefansson reports for a half-mastiff which came from San Francisco, and which had perhaps seldom or never been bitten, that his eyes were completely closed the first year by the swelling, that there was noticeable swelling the second year, and that the third year no swelling was noticeable. The same reactions would probably be typical for humans if they permitted themselves to be sufficiently bitten.

The Eskimos had no adequate way of protection from mosquitoes. For coolness they used in summer clothes which were nearly worn out, hairless, and full of holes. Through the holes the mosquitoes would enter and bite. The skin tents would not exclude mosquitoes, and they tried smudges, even though they really knew, as we do, that mosquitoes can stand more smoke than people. Still, it was sort of half tolerable lying close to the ground breathing fresh air where it came under the edge of the tent, with the interior above filled by smoke.

As a result of the mosquito torture, the second most coveted thing when the Stefansson party visited the Coronation Gulf Eskimos (Stone Age people who had never before seen Europeans) was mosquito netting. (What they coveted most was needles.)

For mosquito protection you need, first, clothes all over your body through which they cannot sting. This means

reasonably heavy garments, no matter how hot it is, and accounts in part for the frequent statement of whites that they have suffered more from heat in the Arctic than anywhere else. You wear leggings on your ankles, gauntlet gloves on your hands, and a sombrero hat to keep the mosquito netting away from your face. The net should have an elastic which grips the crown. Then the material comes out over the brim and is tucked inside of your coat collar. Having it hanging down like a sort of cape is no good—the mosquitoes crawl up under in great numbers.

It is therefore important when you go North to provide yourself with summer garments which have a maximum of insect resistance (bite-proofness) with a minimum of warmth. You must also have fly netting and the means of using it—suitable broad-brimmed hats to keep the netting away from your face by day; suitable arrangements for bed nets to use at night; fly net for windows in tents, etc. Ordinary mosquito netting is not good enough in the Arctic, for the meshes spread. Use bobbinet or something of the sort.

For complete peace at night you should have double protection. First you camp in a tent which has ventilating windows equipped with mosquito netting. Then you sleep under a bed net.

The Stefansson parties used to have a sort of combination tent and bed net for emergencies. This was an A-shaped roof of water-shedding material at least a foot longer than the user (say, 7½ feet for a 6-footer) and about 4 feet wide. From this would hang down mosquito netting on all sides. Mosquito netting tears easily if you try to tuck it under bedding, and so you would have at the lower edge of the netting wall a light cloth, say, a foot of it, to tuck in under the bedding all around.

Smokers have a problem, and so do those who chew and spit. With a wide-brimmed sombrero to hold the net away, you could smoke a cigarette inside the net; but you would have to lift your veil every time you handle the cigarette, and mosquitoes would get in. Pipe smokers will try a long-stem pipe, smoking it through a small hole in the net. Un-

less the hole is a tight fit, mosquitoes will crawl in along the stem.

Fly "dope" may be some good, but few bother with it for long in the North, except people who live in towns and do not have much trouble with mosquitoes anyway. Still, if you have a favorite dope that has worked in New Jersey or in the tropics, you might as well take it along and try it in the Arctic.

SANDFLIES, MIDGES, "NO-SEE-UMS"

After the mosquitoes have been going awhile there develops a pest in some respects worse; these have many names and vary in size and in other respects. Known variously as sandflies, punkies, midges, or "no-see-ums," they are members of the family *Chironomidae* and of the genus *Culicoides*. They are bad in the forest and go farther out on the Arctic prairie than do the blackflies (see below). They are found in numbers large enough to be a pest only on the mainland, although they do occur on Arctic islands.

The breeding habits of the northern species have not been worked out; they probably breed in decaying vegetable matter along streams and around the margin of ponds. They may also breed in rot holes in trees. Some people are very susceptible to the bites and show marked reaction when attacked.

This group of insects are active throughout the summer, their season in many places starting later than that of the mosquito and tending to persist further into the autumn. It is said by some that their annoyance is confined largely to periods when there is little or no breeze. Stefansson's experience is that they will stand a considerable breeze, but that they quiet down upon any chill—mosquitoes bother you at night as well as in the day; midges are worst at noon and in the afternoon, slacking off as the evening cools.

These insects are persistent bloodsuckers, and they are so small that they can go through ordinary screens or head nets. Vanderlip says that in northeastern Siberia he found the only thing which kept them out was 30-mesh wire which he had brought with him for screening gold.

The worst of all with midges or sandflies is that they crawl around on your body like fleas and may bite you anywhere. Here came in what Stefansson found to be the third keenest desire of the Stone Age Eskimos whom he met in 1910 near Coronation Gulf—when they found out that the cotton underwear carried for summer use by the white men was so tightly elastic at the ankles and wrists that it prevented sandflies from crawling under, they became almost as eager to get such underwear as to secure mosquito netting.

The bite of the mosquito merely itches. The bite of the sandfly both hurts and itches.

The third of the major pests, from both the human and animal point of view, is the bulldog, sometimes called moosefly, deerfly, horsefly. These look like overgrown houseflies and bite as if you were being lanced with a surgical instrument, drawing blood that trickles. They are about only on hot days, but are then not restrained by a considerable wind—they can fly almost or quite as fast as a horse can run. You keep them out with mosquito netting and other mosquito precautions. Like sandflies, they stop troubling you toward sundown and are little bother on a cool day.

Black flies, or buffalo gnats as they are sometimes called, are bad pests in certain sub-Arctic and Arctic areas. They are at their worst well within the forest; near the northern edge of the forest their numbers decrease so that they do not constitute a real pest; and they do not go much out on the prairie.

These flies, of the family *Simuliidae,* spend their larval and pupal stages in the water of rapid streams. Several of the species attack man and animals. These begin to appear early in the summer and become most abundant and vicious during the first half of the season, after which they gradually decline. Some people are very susceptible to their bites and may be incapacitated for days after being exposed to a severe attack, the face and arms being badly swollen and some systemic effect in evidence.

BLUEBOTTLES

An insect which bothers though it does not attack is the bluebottle. You find them ready to deposit larvae on meat

everywhere on the continental mainland and in several of the larger islands. They are, for instance, troublesome in Victoria Island—in the interior, however, rather than on the coast.

BOTFLIES

A pest which indirectly affects the Eskimos and northern whites who live by hunting, and owners of reindeer herds, is the botfly or warble fly (Oedemagena Tarandi). It is a bee-like insect of yellowish orange coloration and is one of several parasites that plague caribou.

The fly's season of activity is about 3 months, late June to some time in September. They lay their eggs on the fine, woolly hairs which constitute the under-down of the reindeer or caribou coat. Eggs hatch in 6 to 7 days and the young larvae start boring through the skin, causing dermatitis and abscesses fatal to from 1 to 2 percent of a herd. It is not until the end of October that the holes through the skin attain any size; by February the encysted grubs are about the size and appearance of a white navy bean. The larvae grow progressively and evenly in size until May when they begin to emerge. The chief time of emergence is June.

Reindeer skin is very thin at this season, and the larvae make large openings as they work their way out. Even after the wound has healed, the skin is not strong in these spots. Skins of caribou killed in midsummer are thus likely to have a sieve-like character.

It has been found simple to extract the larvae by squeezing the skin, which causes the reindeer little pain and the operation is quickly done. Theoretically, if all warble flies were thus squeezed out and destroyed, there should be no flies left to attack the animals. Unfortunately, warbles are able to travel considerable distances, and seem to have the power of following animals and catching up with a herd. (It is contended by some that a warble is the swiftest of all flying creatures, insects, or birds. This is hard to prove; for if an insect so small were traveling so fast it would be invisible ordinarily.)

For a number of years the St. Lawrence island reindeer herds were reported free from warbles, although these deer were derived from the same sources as the other Alaska herds.

It was considered that they had been transported from the mainland to the island after all the grubs had left their backs and before egg-laying had started.

The reindeer herd on Nunivak Island was transported after the grub emergence. A letter from Carl Lomen dated August 1, 1940, reports that for many years there were no grubs on this island and that in consequence this herd produced the prize hides of the north. A few years ago, some warble flies were reported—presumably they were blown over from Nelson Island or brought over by some ship or boat—but the herd as a whole is "practically free" from these parasites even now.

A measure of success in warble-control was reported by one owner. After most of the grubs had left the reindeer, about July 1, he drove his herd as far away as possible from the point where the grubs had fallen, the idea being that when the flies emerged from the pupal cases they would not find any reindeer to attack; and, as they only live for a few days, they would soon die. It is thought that the distance which reindeer must be driven should be not less than 15 miles, but the point has not been settled. Lomen has conducted some experiments along this line and agrees, both on theory and on the distance a herd should be driven.

TAPEWORM

Of internal parasites found in the Arctic the most serious, economically, are tapeworms. Many reindeer herds suffer, with a resulting financial loss.

The tapeworm is conveyed to the reindeer by dogs. On St. Lawrence Island, where reindeer dogs have never been used, the herds are said to be free from tapeworm cysts. So far, the only effective control has been in the prevention and cure of them in the dog carriers. No means of prevention in reindeer is known.

Dr. Victor J. Levine, consultant for the United States Public Health Service in Alaska, states that in six summer investigations he has not found Eskimos who had tapeworm.

CHAPTER 6

VEGETATION

SECTION I

VARIETY

Markham, in his *Life of McClintock*, says that there had been at that time (1908) identified from the Arctic 250 species of mosses, 330 of lichens, and 760 of flowering plants. Thus in species the flowering plants outnumber the nonflowering. In tonnage the preponderance of the flowering is still greater. There would be on the average north of the tree line at least 10 tons of flowering plants for every ton of mosses and lichens combined. More likely the ratio in tonnage would be a hundred to one. There is perhaps no island in the Arctic of the size of Puerto Rico or larger in which flowering plants do not literally outweigh the nonflowering. In large islands, like Victoria, they probably outnumber them also in species.

It should be remembered, further, that not merely are the volume and weight of flowering plants at any given moment greater than those of the nonflowering but that the flowering grow more rapidly.

Among the most northerly of the flowering plants, the following have been cited by various authorities, many of them found within a few hundred yards of the north coasts of the most northerly islands: bluegrass, timothy, goldenrod, dandelion, buttercup, poppy, primrose, anemone, alpine chickweed, purple saxifrage, heather, arnica, ferns, shinleaf, bluebell, rhododendron, cranberry, curlewberry, and catspaw.

We mention incidentally and merely as a curiosity the "pink snow" (usually *Sparella nivalis*) which is found at distances as much as 20 miles from shore, and therefore perhaps at any distance from land—microscopic plants

growing in snowbanks. You cannot see the coloring of the snow when you pick up a little of it in a spoon or, indeed, when you stand close to a snowdrift. But go a few yards away, perhaps best 30 or 40, and get the right slant of the sun. Then you see a pink or even red coloring to the drifts, varying and the colors shading into each other. This coloring of the snow eventually proceeds so far that at its height, which is naturally while most of the snow has not as yet turned to water, the hue of the snowbanks is on a cloudy day reflected in the skies, giving them a pink tinge.

Section II

GROWTH

In *The Northward Course of Empire,* 1922, Stefansson has the estimate that (excluding lakes and the Inland Ice of Greenland) vegetation edible to the Arctic grazing animals between the tree line on the continents and the most northerly shores of the most northerly islands averages per square mile of land surface about as abundant as the vegetation edible to cattle and sheep which is found on those tropic-, and temperate-zone lands which are used for stock because they cannot be irrigated and have a rainfall insufficient for cereals and other economic crops.

Grass does not usually grow tall on the Arctic islands. Lieutenant Mecham, however, around 1850, spoke of meadows in Melville Island "resembling English meadows"; and, be it remembered, Melville is well north of the middle of the Canadian Arctic archipelago. Such great islands as Victoria, Baffin, and large parts of Greenland are considerably hotter in summer because larger. Remember, too, that few islands in the polar sea are more remote than Melville from those popular explain-alls, the Gulf Stream and the Japan Current.

The perpetual light and the considerable warmth may, in the case of some plants at least (among them wheat and tuberoses), produce a growth per week of the order of twice as rapid as the maximum tropical—which, if you think of the plant as growing during sunlight, means the same growth per hour in tropics and Arctic, the double Arctic

growth being due to the double number of hours of sunlight per calendar day.

SECTION III

USES

A considerable use of Arctic vegetation as food or medicine might have been made by explorers during the period when it was believed that scurvy resulted from lack of vegetable elements in the diet. That such use was seldom made actually was due to the firm but ill-advised confidence with the explorers had in lime juice as a specific. On a few expeditions one form of green vegetation or another was eaten in connection with the lime juice and always with good results. However, as more fully developed elsewhere, the only expeditions which ever were completely free from scurvy were those which had considerable amounts of fresh animal food in their diet. Now that we understand that complete protection from scurvy is derived from such things as steaks and roasts as easily as from citrous fruits and onions, we have lost the greater part of our motive for eating northern vegetation.

In saying that fresh meat will prevent scurvy as adequately as fresh vegetables we do not mean to say anything about the comparative percentages of Vitamin C, by weight or otherwise, in carnivorous and herbivorous diets. What we do mean is that since an all-meat diet appears to contain twice as much Vitamin C as needed for optimum health, there can be no more danger of scurvy on a fresh all-meat diet than there is on a fresh all-vegetable diet. It is a case of enough being as good as a feast.

The greens that explorers did in fact use against scurvy was most often sorrel, or plants which they thought resembled it. This was because the antiscorbutic virtue of lime juice was supposed to depend on its acid content. Probably an equal benefit would have been received from eating many nonsour local green things that were succulent enough to be readily swallowed.

Berries that are more or less relished by whites and by some Eskimos are found in the Canadian archipelago as far north as Melville Island, and correspondingly elsewhere. The

most northerly of these is the Eskimos paunrat (Crowberry, *Empetrum nigrum* Linn.), watery, of little food value, and, as said, of no significance as scurvy preventive to people already on an antiscorbutic meat diet, though doubtless useful if your party had scurvy from some other diet and you were unable to get fresh meat.

The most northerly berry of significance in the Eskimo economy, and correspondingly available to Europeans, is the salmon berry (Cloudberry, *Rubus Chamaemarus* Linn.). This is yellow in color and looks somewhat like a raspberry, grows somewhat like a strawberry, and is found in numerous places well north of the Arctic Circle. It may be in such abundance that patches of ground look yellow at a distance. This berry tastes agreeable to the average European, delicate rather than pungent in flavor. They can be gathered by the bushel and no doubt preserved for winter in any of the ordinary European ways, or they could be frozen by a quick-freezing process. The whalers used to freeze them at Herchel Island by placing in the natural cold storage houses where they kept their caribou meat. Moreover, frozen on their stalks, many of them can be found still in position during the winter, and even into early spring you can sometimes pick them. Eskimos preserve them in oil—chiefly in western Alaska. In some districts, for instance, Coronation Gulf, they were not eaten, fresh or preserved.

When you come to the edge of the woods, many of the accustomed Temperate Zone berries appear. Currants and cranberries are the chief of these.

In the forest, as in the Yukon, wild strawberries are found and domestic ones may be cultivated.

Indeed, something like half of the ordinary berries of the northern United States can be cultivated successfully in districts like those bordering the Yukon in Alaska and the lower Mackenzie well toward the polar sea in Canada. Reports are available from the United States and Canadian governments and, more recently, from the Arctic Institute of the U. S. S. R.

EDIBLE ROOT

One northern root is used extensively and regularly by some Eskimos and in famines or minor emergencies by others.

This is a species of knotweed—either *Polygonum bistortum* (Tourn.) L., *Polygonum viviparum* L., or *Polygonum fugax* Small. The root is called by the Eskimos by some variant of the word *masu*. In western Alaska and some other places large bags of these roots are kept for winter, soaked in oil, usually seal or white whale.

The chief objection to *masu* is that they are constipating. Western Alaskans recognize the oil in which they are preserved as counteracting this—they say that *masu* are not good to eat by themselves. In Coronation Gulf, where they are seldom eaten except during times of scarcity, there usually is no oil available at the time. So the constipating effect is much feared. The fact that ordinary constipation was rare or unknown among these people made them the more reluctant to face it in connection with hunger.

PLANTS USED FOR WICKS

It is of use to a traveling party to know such things as what makes a good wick for an Eskimo seal oil lamp. The best answer is that most anything serves, if it is dry and finely shredded or not too finely powdered. The use of decayed wood, pussy willow fuzz, moss, and so on for this purpose is discussed in Chapter 7.

As an Arctic prairie fuel,[5] most valuable is the resinous *Cassiope tetragona*. This is a species of white heather, varying in height from 3 to 10 inches. An important element in what might be called polarcraft (by analogy with plainscraft, woodscraft) is to learn during the summer to recognize locations where this heather will grow. Then during the winter you can go with some confidence to places covered with several feet of snow, dig down and find your fuel. A description of the method of using heather is given in Chapter 7.

Willows, tall enough to shelter a camp or for their stems to be of much use as fuel or for house building, are found only on a few of the larger islands, chiefly Victoria Island and Greenland, but perhaps also on Jan Mayen.

However, in many of the Arctic islands the willows are of

[5] In Chapter 7 there is a detailed discussion of Arctic fuels and how to utilize them. Here we mention only those which are of vegetable origin.

considerable value for fuel when you take the roots along with the stems. In many places, even in midwinter, you can find these readily where the snow has been swept from the tops and slopes of hills. Watch as you travel by sledge and pick up those you see; by camp time you likely will have enough for cooking supper and breakfast.

BRUSH

We have mentioned heather and willow for the northern islands. When you get to the mainland there are few rivers which do not contain, a half dozen miles or so from the sea, willows with which you deal as you would with any brush. (These "willows" are true willows as well as alders and other species.)

TREES

The first plant thought of as a tree which you meet coming from the north is in some places the cottonwood. However, this is of botanical rather than practical interest, for such cottonwood clumps are nearly always small. The first "important" tree is, therefore, usually the white spruce, then the black spruce, then cottonwood. After that the number of species increases rapidly.

NORTHERN LIMIT

It was formerly considered that trees became smaller gradually as you went farther and farther north. The actual northward limit is not always arrived at in any gradual way, however. In a sheltered bend the forest belt along a river may be up against a ridge so that in say half a mile you walk from tall and graceful trees up a steep slope to where the trees end abruptly and beyond which there are none—going straight north from there you would reach none until you crossed the polar sea and attained a corresponding climatic situation in Siberia.

The white spruce may be found growing as tall within a dozen miles of the tree line as that species grows even a thousand miles farther south. White spruces, 40 feet high, have been reported within 40 yards of the tree line.

CHAPTER 7

SHELTER, HEAT, AND LIGHT

SECTION 1

"CIVILIZED" ARCTIC COMMUNITIES

When structures of considerable magnitude and of "civilized" type are being erected in the Arctic, the principles and procedures generally will have to be in the main those which we are used to farther south.

The site must be carefully selected. Here the meandering habit of rivers and the cutting of a shore line become important. Especially when there is considerable ground ice, but on the average in any case, an Arctic river will cut its banks more rapidly than you are used to farther south. Fortunately the laws of this process are well understood by geographers and geologists. If you are locating a civil or military establishment on a river you had better choose a place where the stream is meandering away from rather than toward your side, and where that process seems likely to continue for at least a few decades. True enough, the river may get so far away that it will no longer keep the ground thawed for you; but on the whole, that is better than having it undercut and destroy your construction and pipe lines.

Earth that is solid, and gravel, hold the footings referred to below. No footings are possible in swampy tundra and the entire foundation must be on a mat.

Of rare occurrence but important locally is the thaw that comes from volcanic sources. It might well be worth while

to consider the advisability of locating military establishments in the vicinity of hot springs.

Hangars must be located with relation to prevailing winds. A line drawn from the hangar to a nearby village should be at right angles to the likely drift of air on a cold day; for the steam created by the life processes of animals and the housekeeping of people (cooking, etc.) may blanket with fog several square miles of low country to leeward of a village when temperatures run to $-60°$ or $-70°$. At the present airport at Fairbanks, human-animal fog has at times obscured the landing field, with resulting damage to planes.

For deep excavation, if there is plenty of time, you can get good results without the ordinary hot point and other such thawing processes used by northern miners.

Natural summer thawing goes only a few inches down on most land while it is in its native condition. For instance, a meadow in the Arctic, partly because of a layer of damp vegetation, is cooled by the evaporation of the water somewhat as the human skin is by the evaporation of perspiration. Moreover, sunlight is not nearly so fully converted into heat when it strikes the dead grass of last year, light yellow in color, as when it strikes black soil.

Stefansson found in his archaeological excavations that in a country where the thaw of a whole summer would not go down more than 8 or 10 inches he could get in 1 day 3 to 5 inches thaw by removing at the first operation, from the entire area to be excavated, the sod and all that was thawed, and then removing each morning the thaw of the previous day. In that way a 300-inch (25-foot) thawing could be secured by a 100-day summer operation in a district that normally would thaw only a foot. If it is known, then, that an excavation for a large building is going to be needed next year, the work could be done cheaply if carried through the whole summer, or any necessary part of it, this year.

One of the difficulties with modern structures in the Arctic is that, through the removal of grass and the keeping of most earth surfaces bare and black through traffic, thaws begin to go much deeper down into the ground than they used to. Accordingly, corner posts and similar things that are placed

in earth frozen as hard as concrete, say in August of the year of building, may be standing in thawed and soggy ground in August a year or two later.

To insure foundations that won't heave with frost action you need a mat footing, with a very much larger surface at the bottom of the footing than is customary in the States. Very large buildings need an entire mat foundation. (For a full discussion of ground frost see Section I, Chapter 2.)

As implied in Chapter 2, the important exceptions to the rule of permanent Arctic ground frost are connected with unfrozen waters, those of the polar sea, of rivers, and lakes.

From the point of view of sinking wells to supply water the year round, and for the laying of water mains which are to be of 12-month use each year, it is crucial to study for the intended locality the character of the ground thaw.

On the north coast of Alaska you are likely to reach unfrozen ground at a 20- or 30-foot depth 50 feet from the shore line. The permanent value of this, however, is negligible, for in most parts the sea is cutting away the land at such a rate that it would be only a few years till a system of water mains, for instance, laid in such ground would have to be moved or abandoned. Generally speaking, the importance of ground thaw along the Arctic sea is, therefore, negative—in the sense that if you want an excavation, as for permanent cold storage perhaps, you had better be careful that it is made far enough from the sea.

The thaw may extend as far from lakes, on the average, as it does from the sea—perhaps farther, since their waters are warmer. The shore lines of lakes are usually almost stationary, so that the ground thaw can there be utilized for water supply by wells and for burying permanent mains. Near some lakes the thaw comes near or to the surface.

The best understood situation with regard to the removal of ground frost by rivers is in the case of the Snake which enters the sea by the town of Nome, Alaska. A few miles back, where the valley is about a mile wide, it seems that practically anywhere in the valley you strike permanently thawed ground at about 30 feet down. Where there are willows, the thawed ground comes nearest the surface, of course, because

in a generally open country these willows catch a lot of snow and hold it as a blanketing, giving every opportunity for the ground water to thaw the soil and to keep it thawed.

Here the meandering habit of rivers becomes important. Fortunately the laws of this process are well understood by geographers and geologists. If you are locating a civil or military establishment on a river, you had better choose a place where the stream is meandering away from rather than toward your side, and where that process seems likely to continue for at least a few decades. True enough, the river may get so far away that it will no longer keep the ground thawed for you; but, on the whole, that is better than having it undercut and destroy your construction.

For reasons already stated or implied, it is most important that after the laying of your water mains (see below) or the sinking of your wells you shall keep for the ground the same protection which it had and, if possible, increase the protection. This means that you must not destroy bushes. If possible, you should plant more willows, or perhaps white spruce or cottonwoods, to extend the area that holds the snow. If this fails, or if it is considered too costly and slow, you could attain, at least in windy places, the same result with snow fences built and used on the principles well known to the railways which traverse the prairies of the United States and Canada.

The laying of water mains naturally has problems connected with ground temperatures. At or near the surface these temperatures become the same as those of the weather and may accordingly be —60° in the forested parts of the sub-Arctic and —50° near certain of the northern coasts. What might be spoken of as the indigenous temperature of the ground itself is probably around 10°—at least that is the temperature 40 feet down at Cape Smythe (Barrow), Alaska; similar figures are given for the underground coal mining operations in Spitsbergen.

It would appear, then, that in winter cold decreases as you go down and that it might be advisable to have mains deep. However, the depth at which you attain 10 above zero is so great, and that temperature itself so cold, that the situation is academic. Mains, in practice, will have to be near the sur-

face on all sites where ground frost is permanent. They should be well insulated. This is sometimes accomplished by having a smaller pipe inside a larger one, with an air space around, or there may be some form of insulator packing around the pipe itself, whether or not it is surrounded by a larger pipe. It is important to keep running large quantities of water through a main when temperatures are low.

Hydraulic miners, working at low temperatures, have comparatively little trouble because of the rapidity with which the water passes through their pipes, a warmth slightly above freezing then sufficing to neutralize the chill that reaches the outside of the pipes.

In some cases the problem of freezing water mains has been solved by running through the same tunnel or large pipe both the water lines and steam lines from a central heating plant.

There are various applications of heat and electricity to water systems. These can be borrowed practically unchanged, for use in the very coldest Arctic and sub-Arctic localities, from the practice of such cities as Winnipeg, which occasionally have temperatures of $-50°$. True enough, one of the principles in Winnipeg is to bury mains at something like seven or nine feet, the limit of frost, since the ground is not permanently frozen. Apart from this, Winnipeg deals with winter temperatures under natural conditions practically identical with those of the Arctic. And, of course, cities like Fairbanks have had a long enough experience to develop a suitable technique through methods of trial and error.

NOME, ALASKA, WATER SYSTEM

A statement on the water system of Nome, Alaska, has been furnished by Carl J. Lomen:

"Nome has water mains for general use and a separate system for the fire department of the city.

"The water for household use is piped from Moonlight Springs in a wooden pipe line of some 16 inches in diameter—wooden staves banded with iron. The pipe line ends at D Street, and from there the pipe lines are of iron and only a few inches in diameter. The mains are less than three feet below the surface. The exposed pipes leading into the homes are of ½ and 1 inch diameter.

"The pipes are not insulated by packing, though they are laid in a wooden gutter, the top of which is about even with the surface of the street. The mains * * * could not be protected against frost even though sunk deeper because of perpetual frost to bedrock.

"During October, when low freezing temperatures may be expected, the custom has been to open all faucets and permit the water to run continuously. This continues until an exceptionally cold snap freezes the entire system. Many householders are so anxious to keep a flow of water going that they permit the pipe lines to freeze each year, and (because of bursting) many lengths have to be replaced next spring. Following the freeze the watermen come into their own and for some 6 or 7 months river or spring water is delivered to the homes in large water tanks on bobs drawn by horses. From tank to ditches the transfer is in 5-gallon cans.

"In the spring the water company send out their gangs, who thaw out the town pipes. They use long iron points through which they pass steam. It requires several weeks' work.

"The fire-department mains are a bit deeper and, as I recall, are also iron pipes with a square box covering. This system is drained in the fall of the year and kept clear all winter. When a fire alarm comes in—during the winter season—the engine at the fire house commences pumping to fill the water mains. The 'Chemical' rushes to the fire to hold the flames in check until the mains are filled and sufficient pressure is secured to reach the fire with water. As soon as the fire has been extinguished, the firemen again drain the system, thaw and reassemble the hose, and make everything ready for the next call. It depends upon the distance the fire is located from the fire pump as to the length of time which will elapse from the sound of the alarm to the play of the water—from five to fifteen minutes."

CONTROLLING ROOM TEMPERATURE BY GRAVITY

It might be worth while to experiment with adapting to buildings of European-American type a principle used by the Eskimos, that of entering a room from below instead of from the side.

Where you desire to maintain within a building a 60° temperature against −60° outside, there is a sudden and rapid interchange of the inner and outer atmospheres when you open an ordinary door perhaps 7 feet high and 3 or 4 feet wide. Through the pronounced difference in gravitational values, quantities of the chilled air rush in along the floor, in appearance a dense cloud of steam, and equal quantities of the heated air, also steamlike in appearance, rush out through the upper half of the opening.

If instead of a vertical door in the side of your room you had a horizontal door (a trap door) of the same dimensions in the floor, you could have it constantly open and less cold would enter in an hour (by diffusion of gases) than enters in a minute through the side door. There would also be full relief from violent changes of temperatures.

It might seem that this problem would be still better worth facing in shops than in dwellings. Assume, for instance, you desire to maintain a constant 40° temperature in a hangar or workshop for repairing airplanes. If you open at −60° a side door big enough to admit a plane, you will not merely drop the interior temperature very low but there may occur such chilling of metals already in the shop that when you raise the temperature again by the use of fuel there will be sweating of metal surface. This may produce rust; perhaps water may gather in some hidden place, so that when the machine or instrument is later taken outdoors freezing up may prevent its proper operation.

If, instead of entering through a side door, the plane were to come in by ramp or elevator from below, there would be no great change in temperature within the hangar, certainly not enough to produce sweating on metal things already there.

This argument of sweating applies, of course, only to what is already in the shop or hangar when the door is opened. It cannot apply to the machine just brought in, which will be iced all over, later becoming wet when the ice thaws.

The sweating of metals as they pass from cold to warm is one of the most serious of Arctic problems. Every effort should, therefore, be made to devise procedures by which all instruments and machines can be repaired and serviced out

of doors, or in sheds which differ from the outer air in little except that they keep out the wind.

For the Arctic summer there is no special problem about living in average temperate zone style, except that in small villages you must be especially careful with mosquito protection.

MOSQUITO PRECAUTIONS

This will be on the same style as used farther south. Where there is trouble with sand flies you need for windows and screen doors a mesh considerably finer than for mosquitoes, say each mesh only one quarter as large.

HEAT RELIEF

During the short period of intense heat in certain inland districts, it may be well to make provision for cooling off in basement rooms. Where the walls of these are up against the earth, and if the walls are of material that is a good conductor, you have a cooling of the air by the coolness of the walls. This is particularly important in hospitals.

NATURAL COLD-STORAGE ROOMS

In connection with an establishment of considerable size, such as military posts, arrangements could probably be made for natural cold storage of food products by a system more reliable, as well as less expensive, than the artificial. The chill you need, say 10°, is supplied by the permanently frozen ground.

When white men construct storehouses in the Arctic, as, for instance, the American whalers at Herschel Island, they commonly begin with a fundamental error—the storage chamber is cut into the side of a hill and they enter the cold room through a door in the front wall. Then you have a reversal of what we discussed for winter—each time the door is opened in summer the cold air from inside flows out through the lower half and the warm air from outdoors flows in through the upper half.

Probably the first Alaska use of the right principle by whites was at Cape Smythe. This came about through accident. The Army expedition of 1881–83, under Lieutenant Ray, sank

a shaft for earth temperatures. After they moved out and the house and all other property they left came under the charge of Mr. Charles D. Brower, he enlarged the bottom of the shaft into a chamber, which had a year-round temperature of about 10° F.

Since warm air is light and cold air heavy, and the shaft to the storage chamber vertical, you can enter and leave this Barrow storehouse a number of times on the hottest day without materially changing its temperature. Men, if necessary, can work down in it all day without closing any trap or other door.

If the cold-storage chamber is to be part of a building proper, the subcellar idea is what you use. The storage chamber would then be entered by a stair from the cellar just as the cellar itself is entered by a stair from the ground floor.

GROUND ICE AN ADVANTAGE

If you are choosing between localities for building a civilian town or military post in Alaska, the Geological Survey may be able to tell you from previous surveys that the land near one of them contains ground ice. This can be an advantage, for in such places storage chambers can be excavated with little more trouble than if they were being hewed from an iceberg.

SHORING UNNECESSARY

Whether cold rooms are hewn or thawed out from ice or frozen earth, there is no shoring necessary, unless possibly in rock of poor quality. Mud that would be semiliquid when thawed makes ideal storage walls when frozen.

SECTION II

CAMPS

a. Houses

The principal type of emergency house discussed is of earth and wood, but the fundamental principles of this type apply to the others. Some of the principles are:

The wall framework leans in slightly so that the earth hugs it through force of gravity. Walls and roof should be so

thick that no appreciable heat gets out except through openings deliberately left for ventilation. All the fresh air, then, enters through the ventilating system, which is gravitational and therefore completely automatic. In practice this means that you enter the house from below through a permanently open trap-door which is also the ventilational air intake.

GRAVITATIONAL VENTILATION

There is always some ventilation by diffusion of gases through any opening into a chamber, but the amount of fresh air which enters through a trap door in the floor, no matter how large, is in the main determined by the amount of air that can escape upward from the house. Therefore, you control the effectiveness of a large intake by varying the size of a small exit in the roof.

With this type of house, as with others, you should remember the general principle that when in doubt as to a building site in treeless country, avoid a lee. This goes against the grain with most temperate zone people—they try to find a shelter or to build one. In the Arctic (as more fully stated elsewhere) it is frequently a matter of life and death to avoid lees. This is one of the reasons why Indians of the northern fringe of the forest, habituated to woodlands, and conservative, are perhaps the worst possible companions when you go out upon the Arctic prairie. The propensity for camping in a lee accounts for much of the trouble, hardship, and loss of life among early and recent travelers who have used Indian companions. (See more detailed discussion under Tents, later in this chapter; also Section V, Chapter 10.)

Wood and earth are the best local materials when you can get them, and it is possible to get them in many parts of the Arctic.

On a coast, where driftwood is obtainable, you erect four posts at what are to be the corners of your house. These need crotches. Simplest is to find trees with roots on them, whereupon your posts are four stumps with the roots up. You make them stand by digging holes for them in the ground, which can usually be done even with the most primitive tools. You may have to use some ingenuity, however,

as, for instance, making several successive fires. You thaw the ground a few inches each time, scrape away the thawed ground with the ashes, repeating until the hole is deep enough.

This is the primitive way, used when you have no modern appliances. Alaskan and Siberian miners use "points." You make steam in some kind of a boiler and run from it a hose which terminates in a metal pipe through which the steam emerges at or near the tip. With this type of gear you can thaw a small hole, not much bigger than to fit your post; if you use the method of successive fires you thaw out a basin that is deep enough, stick your post in the middle of it and pack around with the thawed earth which, of course, will soon freeze if the weather is cold. If the weather is not yet cold the post has to stand through some factor of rigidity introduced in the construction of the house.

If the post hole is of medium size, as usual with Eskimos when a house is built in thawed ground (near open water), you wedge or fill in with whatever under the circumstances seems most suitable, perhaps slivers of wood or stone. If it is necessary to use earth which depends for its supporting power on being frozen, then, after dampening it, if necessary, you will have to make sure that it is covered by enough more earth so that a thaw (caused by the house being warmed during occupancy) does not loosen it.

The posts firmly planted, you lay four logs across to make the tops of your four walls. The rest of the wood part of your walls will be up-and-down sticks, perhaps logs split in half and propped up, leaning in just enough so that loose earth thrown against them will not fall away.

You now determine, according to materials on hand, what kind of roof to have. The most common Eskimo type is also one of the best. In a square of from 3 to 5 feet you plant in the center of your house four posts so much taller than the corner posts that the slope will be considerable, anything from 15° to 30°. At the top you connect these posts by four logs, as in the case of the walls. The square between—3′ x 3′, 4′ x 4′, or larger—is going to be your skylight. A particularly strong rafter runs from each corner of the window frame to each corner of the wall. The other rafters will rest one end

on the wall beams, the other on the window beams, or on the main or corner rafters.

The next thing is to determine where your door is to be; for, before you pile earth on the walls, you must dig a trench, not necessarily more than 3 feet wide, and bridge it over with wood where it is to go under the wall. The outside entrance to the alleyway should be 10 or more feet away from the house so that the down slope shall not be too steep. Walls and roofing of the alleyway can be as flimsy as you please so long as they keep the wind out. The outermost door need not be weathertight, for even if a little snow drifts in during a blizzard this will not go far into the alleyway and is easy to shovel out.

You now shovel or pile loose earth or broken sod against the framework so that the walls will be perhaps 4 or 5 feet thick at the bottom, and perhaps 12 or 18 inches thick at the house eaves. (Eskimos usually have the walls only from 3 to 5 feet high, which greatly simplifies the heating problem—the house is, even so, fairly high inside at the center, perhaps 7 or 8 feet.) Your rafters will be covered with earth to a thickness of anything between 3 and 6 inches. Should it be impossible to find rafters strong enough to hold that load, you can perhaps make out by going inland and finding some tall grass, moss, or other fluffy vegetation. With 2 or 3 inches of dead grass or moss on the roof you need merely enough earth on top of that to hold it down and for windproofing—say, 2 inches.

In the comparative warmth of early and late winter, when temperatures go above zero F., you will have to depend for daylight entirely on your top window, which may be made of thin white cloth, if you have any, of a thin skin made transparent by rotting the hair away (i. e., parchment), or of the intestines of large animals slit lengthwise and the strips sewn together after the inner membranes have been removed.

In midwinter, when temperatures seldom go above zero F., you can use an ice window. This would melt if it were in the roof and has to be in a wall. If your building looks forward to such a window, you will have left a space for it, somewhat as for a narrow doorway, with a temporary covering until the weather gets cold enough. Then you cut ice for your window

from the surface of some pond or fresh-water stream. If you use salt-water ice, you get somewhat less light, for it is milky rather than glassy.

If the occupants of the house are scientifically-minded, they get some amusement and a little extra light by applying the principle of lenses, curving the surfaces of the ice window panes.

To an extent, the ice window is self-protecting. If the weather outside is too warm, or the house overheated from inside, melting will take place. The thicker the window the more quickly it begins to melt; as it thins, chill from the outside gets increased play until finally thawing stops before a hole is melted. Only if it is warm both outdoors and in will a hole form. To prevent that you put out your fire or protect your window from inside warmth by skins or blanketing, thus giving play to the cold locally stored in the earth around the window. If that fails, you just have to get a slab of ice for a new pane after the warm spell is over.

METHODS OF SECURING ICE WINDOW PANES

You secure ice that is right for windows in a number of ways. Fresh ice is more translucent than salt, so river or lake ice is normally used. If you know in the autumn that you are going to spend a long time at a given place, it is well to cut ice from a lake when it is about 2 inches thick, dividing this into a number of panes, either of the right size or of excess size so that they can be cut down later. You stack these up with slivers of wood or other protection between the layers; otherwise they might freeze together. Then you store them where a thaw is not likely to reach—perhaps you cover them with a pile of skins or with moss and then snow.

Even in midwinter you can usually find thin ice. Look for a stream that was frozen over at a high level, the water then sinking away from the ice. This is common on many small rivers.

Another way of getting a window pane is to chop a hole in river or lake ice that is a little bit bigger than your intended window. Remove all ice fragments and snow, so that perfect ice will form, and then wait until the gap so artificially

made has frozen over. When the ice is of the thickness you desire you remove it by sawing or by gentle chipping along the edges.

If thin ice is hard to find, thick ice will serve. Sometimes you start with windows 12 or fifteen inches thick, but that does not last long if they are near the cooking apparatus which melts the inside and keeps on melting until a point is reached where the outer cold balances the inner heat.

We suggested above that windows could be made with lens surfaces. This can be done by chiseling as a sculptor chisels marble. It can also be done, of course, by melting, as with a piece of iron or sliver of rock that you alternately stick in the fire and apply to the ice. In a similar way, a heavy block of ice can be thinned down as desired for a window.

The floor of the house can be just earth, as it frequently was in pioneer sod houses of the western United States prairies. It can be covered with sawdust shavings or a brush matting. But in most cases you would follow the commonest Eskimo fashion by splitting logs and laying them with the round backs down, adzing or whittling the flat surfaces so that, if not smooth, they shall at least be without slivers. These logs can then, if desired, be covered, or parts of the floor at least, with skins or whatever you have. However, you will use for a proper floor cover only rawhides without hair. Skins with hair on them will cover those parts of the floor only where men sit down or where they sleep.

Some Eskimos do not use anywhere a door that can be closed, not even at the outer entrance of the alleyway. Their dependence on gravity control of the balance between outer and inner air is in those cases complete. If you have a door, it must not, of course, be weather-tight; for ventilation depends on it. (See below.)

Usually it is advisable to build a house on ground level. Under special circumstances, as when you build in the side of a hill, the dwelling may be partly a dugout.

In either case the entrance should be through a tunnel dug 3 or 4 feet deeper than floor level. Eskimos frequently have such alleyways 20 or 30 feet long, sometimes with alcoves. Either with or without alcoves, they are useful for storage, for dogs to sleep in, etc. Sometimes one of the alcoves is

an auxiliary kitchen—you may think cooking everything within doors would overheat the house; or you may be in a hurry, and then a bonfire in the outer kitchen will serve for quick boiling or roasting.

As said, the outer door of your alleyway must not be weather-tight; it need not be closed at all. The rest may be walled and roofed as high as you please, but where you stoop to get in under the wall the tunnel is necessarily low. Passing that constriction, you stand up inside the house in such a way that to inmates you are visible above the waist. This means that in the floor there is an entrance, always open, say 3 or 4 feet wide and running 5 or 6 feet into the house.

To have the alleyway extend thus indoors is sometimes convenient. When the weather is $-50°$ outside it may be anything from $-20°$ to $20°$ at the bottom of your entrance when the interior of your house, 5 to 8 feet higher, is $60°$ or $80°$. This means that you have a cold storage chamber right indoors. A piece of meat down there, suitably protected from dogs, will remain frozen and fresh for days—indeed, until the weather outdoors becomes so warm, say around zero, that the heat of the house is able to crowd down into the entrance and produce a thaw at alley floor depth.

Ventilation should be of the Eskimo gravity type. In the roof, just to one side of its peak, you have a wooden chimney made of a hollow log, of boards, or something of the kind, and from 5 to 10 inches in diameter, according to how big your house is and how much fuel you burn. For increasing house temperatures you decrease this opening by sticking something into it, as a wad of skins or a mitten. To decrease indoor warmth you increase the size of your ventilator opening. The flow rate of the warm air up through this top ventilator determines the rate at which cold air can enter from the bottom, through the trap door.

With the cold air entering by a floor opening of, say, 15 or 20 square feet area, and the warm air leaving by a roof ventilator of less than a square foot in cross section, you can have no draft or air motion that is readily perceptible in the room. The cold air just wells up slowly through the trap and spreads evenly over the floor—unless something within the house is in violent motion, stirring up the air, as, for instance, people

dancing. But go on top the roof, hold your hand a foot above the ventilator chimney and you feel so strong a draft that it seems to press your hand upwards.

Ordinarily house temperatures vary so with elevation that you can regulate body temperature by the level which you occupy. For instance, when you stand in a house the air around your shoes might be at 40° F., around your waist at 50°, and just above your head 60°. Stefansson says that he never measured this gradation in a wooden house but that he did measure corresponding gradations in a snowhouse. At any rate, it is common practice in this type of house to cool off by lying down on the floor. (Eskimos frequently keep wooden houses at 80° to 100° F. temperature as measured, say, 1 foot below the peak of the roof.)

When material is available (perhaps gasoline tins) out of which a stove and stovepipe can be constructed, a stove is much better than an open fireplace when the fuel to be burned is wood or coal. In many cases, however, the traveler is forced to depend on fireplaces.

FIREPLACES OF EUROPEAN TYPE

There are two main types of fireplace, the Eskimo-Indian and the European. The European need not be described in detail, since its principles are well understood. You make that fireplace in one wall of your house. If it is used, you may safely forget nearly everything that has been said about ventilation; for the fireplaces takes care of it in one way though spoiling it in another. A chief drawback of a European fireplace is that it provides too much ventilation, so that at −40° or −50° it is extremely difficult to keep a house comfortable. The fire does not throw enough heat into the room to counterbalance the cold that is pulled in with the air which replaces the current that goes up the chimney.

FIREPLACES OF ESKIMO TYPE

In spite of drawbacks, which will appear, the Eskimo type of fireplace is better for cold weather use than a European, though a stove is better than either. This fireplace is in the center of the house. It can be just a spot on the earthen

floor, but stones are advisable both for convenience while the fire is burning and to absorb and preserve warmth. While a fire on this central hearth is going, you have to remove the window covering at the peak of your roof. Even so, in very cold weather a central fireplace keeps the house warmer than a European wall hearth; for it sucks in no more cold air than the European while throwing out heat not merely in one but in all directions.

When the cooking is over, or when the heating of the house has been accomplished, you throw out of doors the least smoking embers and cover the roof aperture in a hurry so as to imprison as much heat as possible.

Stefansson has described living in a house so heated in northern interior Alaska. They were comfortable all day and all night as a result of cooking just two meals, breakfast and supper, on an Eskimo central fireplace. Heat for the rest of the time was furnished by the gradual cooling of the stones of the fireplace.

Another plan is to do your cooking in a specially constructed shelter out of doors and to heat loose stones during the cooking. When the food is brought in, you also roll into the house half a dozen of these toasted small boulders. They radiate warmth for hours. A house may be fairly comfortable with two heatings, morning and evening, though commonly there are more—partly for amusement and busy work.

DANGERS OF CHARCOAL

There is a temptation for Europeans, because of inherited ideas, to try to improve on the Eskimo method by developing practically a smokeless charcoal to burn on the central fireplace. This is all right if you are very cautious about monoxide poisoning, with which we deal in Section V, Chapter 10.

If there is more animal oil than you need for food, burning it Eskimo fashion is, if you really know how, a better way of heating and cooking than the use of wood, even where suitable firewood is abundant. There is the drawback to oil lamp cooking that pots are slow in boiling; but the advantage that the lamps give light as well as heat. With proper trimming there is no odor and no smoke, if you burn fresh fat. There

will be an odor from fermented fat, but it is not unpleasant to those used to it—a few Europeans like it from the start, most will not notice it after they have been in the house ten minutes, and nearly all will eventually get to like it insofar as they smell it at all. (The method of burning fat is described in Section III of this Chapter.)

It is not necessary to describe other houses in detail if the principles of the usual earth-and-wood coastal Eskimo house are fully understood. You simply adapt yourself to the materials obtainable and to the conditions. In one case, for instance, near the center of Melville Island, the third Stefansson expedition could find no stones, bones, or other materials that would support a heavy roof, nor was there anything available as a framework to support earthen walls. They, accordingly, dug themselves into a hill and sewed skins together for a roof. The skins were light enough to be supported by some bamboo poles and similar things which they had on their sledges. The campers spread several layers of skins over the initial layer, but the total weight was, of course, much less than even the thinnest useful earth covering.

In order that the roof should not cave in under weight of snow during the winter, they selected for the house site the top of a hill so that there would be no lee anywhere in which snow could accumulate. The house roof had to be nearly flat, for if there had been an A-pitch to it this would have produced a lee, making inevitable a heavy snow accumulation on one side, if not both. They erected no other structure anywhere near, allowed no sledges to stand about, and were so successful with the various precautions against snowdrifts (elsewhere described) that the weak ridgepole never suffered a breaking strain.

On most Arctic coasts something can be found to support heavy walls and roofs—rib and shoulder bones of whales, etc. In such cases the buildings have to be small or have to be divided into many separate compartments.

Generally a party arriving on an Arctic seacoast without house-building material or fuel of its own should, if it has to winter, do so on the coast. For game is likely to be more abundant there than inland—seals and polar bears. One of the above types of house will then be used.

But should there be a reason for leaving the coast, as, for instance, absence of sea game and the likelihood of land game or of superior fishing from lakes or rivers inland, the chances are that the best camp to build would be of the Eskimo hemispherical house type, with a framework of willows. (It is customary for northern travelers to call "willow" anything not a cottonwood or a spruce.)

Willows descend almost to the sea along many northerly continental rivers and will be found as driftwood north of their growth limit along the lower courses and deltas. Tall willows are rare on Arctic islands, however. There are willows suitable for houses of the type about to be described on some of the rivers in the southern half of Victoria Island and in southern Greenland; there may be on Novaya Zemlya. Probably all other northern islands are lacking in suitable willows.

A willow framework is not strong enough to sustain a drift of snow. Therefore you must build your house either in so extensive a stretch of willows that there is no drifting snow where you are, or else in an exposed location where there are no rocks, cliffs, or other things behind which snowdrifts may form.

SHAPE

For maximum interior space with given materials, for strength, ease of heating, and for some other advantages, your willow house should be dome-shaped. If necessary it may be a sort of oval dome—one diameter considerably longer than its transverse diameter.

FRAMEWORK

For a 10-foot diameter you take a pair of willows each from 7 to 9 feet long, plant their big ends 10 feet apart and bend them toward each other, lashing the overlaps together with twine, thong, roots, or strips of bark. Take a second pair, place, bend and lash them similarly and so that they cross the first pair at right angles. Where they cross you fasten them together. Parallel to one of the pairs, some 15 or 20 inches away, you place similar pairs similarly bent and lashed. At right angles to these again you put in successive

pairs of willows until you have made the equivalent of an inverted basket, in most or all cases lashing the willows wherever they cross each other. (Especially in small houses the framework need not be as regular as here described.)

COVERING

The willow frame is not strong enough to support a covering of earth. You therefore use skins or fabrics and provide warmth on the air-space principle by using grass or moss outside. If there are no skins or fabrics you can manage just with moss and grass, but the meshes of your framework must then be small.

The skins covering your inverted basket may overlap more or less shingle-fashion, with a cap skin at the center of the dome; or the covering may be of skins that have been sewn together. If cloth is used, and if many kinds are available, prefer the one that is most nearly airproof.

Outside of the tent covering you put grass or moss enough to make a thickness of 2 or 3 inches and outside that a second covering. You next bank with snow. It may be advisable to shovel a certain amount of snow all over the house, including the center of the roof, for the willows are amply strong enough to support this although not strong enough to support a deep snowdrift.

WINDBREAK

If the house is built on the open prairie, provide a windbreak, as described under Tents. The snow that falls on a house protected by such a windbreak settles lightly and not in quantity to produce a cave-in.

DOOR

As to shape, size, location, and manner of closing, the door of the dome house is like that of the dome tent, described hereafter.

WINDOW

The windows are about as already described for earth-and-wood houses—if of ice they are low down in the wall, if of skin they are high up in the roof.

HEATING

We said that the usual and best fuel for heating Eskimo houses on a coast is animal fat. This is practically never obtainable inland, where you almost necessarily heat by either of two methods, both already described—the central fireplace below a central window, the covering of which can be removed; or stones heated outside and rolled in.

b. Snowhouses

The Eskimos seemingly have at least one fundamental discovery to their credit. They are the only people, whether of ancient or modern times, who have succeeded in building a dome without the use of scaffolding during construction.

It has been claimed that the Eskimos have been able to dispense with scaffolding because the blocks of snow are sticky, clinging as if with mucilage. But, in fact, the second block of a snowhouse, and every block after that, stands because it has been placed in such a position that it cannot fall without first breaking. Give blocks considerable time and they do begin to adhere to each other; but touch them immediately after they have been set in place and you find that disengaging them requires merely overcoming the force of gravity.

MISUSE OF WORD IGLU (IGLOO)

There is a doubly unfortunate practice in our books and speech to use the Eskimo word *iglu* (*igloo*) for a special type of house which we suppose to be or think of as being peculiar to the Eskimo. The first trouble is that we are then making a narrow, specific use of one of the broadest terms possible; for in the Eskimo language, which is one from east Greenland through Canada and Alaska to eastern Siberia, iglu means a temporary or permanent shelter for man or beast. To an Eskimo a railway station, cathedral, farmhouse, and cow barn are iglus. (There are districts, or it is claimed that there are, where the word is slightly narrowed; but even then only to meaning a temporary or permanent shelter for human beings, as opposed to animals.)

A second difficulty with our use of iglu is that a writer will

call an iglu that type of Eskimo house with which he is most familiar. If he has been in northwesterly Greenland he tells you that an iglu is a house of earth with a framework of bone or stone. If he has been in King William Island he tells that an iglu is a house of snow. From Alaska he will tell you that an iglu is a house of wood and earth.

Not understanding the language, travelers from Alaska and Greenland will argue this as a linguistic point, saying that an iglu is not a snowhouse at all. Similarly, a traveler from the central district, unless a good linguist, will come back supporting the popular view that an iglu is indeed a snowhouse. And each can prove himself linguistically right by questioning Eskimos, who will point to either a snowhouse or an earthen house and call it an iglu. What they overlook is that the same Eskimo would also speak of the White House in Washington and the Empire State Building in New York as iglus.

CORRECT USE OF IGLU

In a district where only one house type is in use, iglu is employed normally; the word may even be used locally in usual speech for whatever type is more common than another. But no one who desires to be precise will do so—they will use specific words like our skyscraper, church, or cottage. An example of correct Eskimo use, taken from the Mackenzie dialect, is *tupermik iglukaktok*—he has a tent (tupek) for a dwelling; *apujamik iglukaktok*—he has a snowhouse for a dwelling. In Coronation Gulf, where snowhouses are in winter the regular thing, you will often hear them spoken of as iglus. However, in spring and autumn when some people are in tents and some in snowhouses the language will be more specific. The name there for a snowhouse is *ini*. The second of the above sentences will, then, be *inimik iglukaktok*—he lives in a snowhouse.

In this Manual, accordingly, we never use the word "iglu." In fact, we shall use only two Eskimo words, and them because they are specific names for peculiar things of Eskimo invention and because they have been taken into our language in their correct Eskimo meaning. These words are "kayak," a

small, covered-over skin boat; and "umiak," a large dory-type open, skin boat.

There are several theories of how the Eskimos developed the snow house, none of them with sufficient probability over the others to be worth detailing except in an extended theoretical work.

Though the dome snow house was probably an Eskimo invention, it was never universal among them. It seems likely that more than half of the Eskimos of a hundred years ago either had never heard of a dome snow house or knew of it only by such remote hearsay that it was either unreal or disbelieved in. A remaining 25 percent knew of the snow house by fairly definite hearsay concerning use by groups not very remote. Another 5 percent or 10 percent knew how to build snow houses but used them only in emergencies. The remaining 15 percent or 20 percent lived in snow houses during the intensely cold part of each winter, when temperatures averaged lower than zero F. and seldom went above 10°.

Geographically the domed snow house is unknown, except recently through hearsay and through photographs and movies, to approximately 1,500 Eskimos who live in northeastern Siberia, to about 7,000 in southern, western, and northern Alaska, to about 17,000 in Greenland, and to a few hundred in Labrador. Several hundred Canadian Eskimos around the mouth of the Mackenzie, who now do not use them, are descendants of people who a generation ago employed snow houses in traveling, though they lived in other houses.

At the margins of the snow-house area there are, then, transition belts where people know how to build snow houses but seldom use them. The builders there are not such experts nor do they make proper use of the snow dwellings—they have forgotten, or have never understood, the technique of comfortable snow house living. These transition groups are, as said, in the west, the Mackenzie Eskimos. In the northeast are the only people of Greenland who have snow houses. They are a transition group in the sense that they normally live in other dwellings, that they make snow houses rather badly and do not seem to be really comfortable in them—at

least not in comparison with the true snow house dwellers. The southeastern transition group is on the Ungava peninsula between Hudson Bay and the Atlantic. Apparently there is not a real transition group at that southeasterly corner of Eskimo territory which is west of Hudson Bay—even the most southerly people there are rather good at snow-house building and use.

THE REGULAR SNOW HOUSE DISTRICTS

The Mackenzie transition belt extended east as far as Cape Bathurst, or even Cape Parry. East of Parry has been, for nearly or quite a century, a belt from 100 to 200 miles wide that was not, properly speaking, inhabited. Then, at or before reaching Cape Bexley, you come to the real snow-house dwellers who, excepting their summer tents, have no housing other than of snow. Snow continues the winter house northeastward into Victoria and the other inhabited islands and eastward along the mainland coast to the Hudson Bay district and Baffin Island, with some use of snow houses in Ungava east of the Bay.

The true snow house people, those with whom domed snow dwellings are standard and not a makeshift, are at present less than 10,000 in number—perhaps only 7,000 or 8,000. Two hundred years ago when the Eskimo population may have been 100,000 to 200,000, the ratio of snow house dwellers to the rest was probably not very different from what it is now.

Approach toward perfection in dome snow house building varies with districts. Obviously it must vary also with individuals.

Some of the poorest dome houses are the ones best known through pictures. As said, the Eskimos of northwest Greenland use snow houses merely as emergency dwellings or when traveling, but these are the group who have been most frequently visited by explorers—this because, since the beginning days of photography, attainment of the Pole has been a chief northern endeavor and it was realized early that Smith Sound is one of the most favorable gateways to the Pole.

The Cape York or Smith Sound snow house is frequently not merely irregular in shape, showing lack of individual skill or knowledge of principles in the builder, but is even of

nearly conical rather than dome shape, which shows that the community lacks a fundamental grasp of principles. For a house that departs notably from a perfect dome shape will necessarily begin to cave in soon after it is finished.

The Cape York house, therefore, is necessarily built of fairly strong (hard) snow blocks, for otherwise caving would be immediate and disastrous. Even when the blocks are strong the house cannot be very large because the strain toward cave-in increases rapidly with the size of that area which does not conform to dome principles.

Approximately speaking, snow houses improve architecturally as you go west or southwest from northwestern Greenland into the Canadian archipelago and to the North American mainland until they approach nearest perfection between King William Island and Coronation Gulf. In that locality, when snow is nearly perfect and the community's best craftsmen are working together, a dome can be erected for assembly purposes which is 18 or 20 feet in diameter and 9 to 11 feet high (the builders, toward the last, standing on temporary snow platforms). Such houses are occasionally without sign of cave-in a week or even two weeks later. There seems no evidence available of how far after that the settling can continue without an inward bulge appearing. (See below on Building a Dome Snow House.)

A practical inference from the above is that a traveler cannot expect natives to build dome snow houses for him except in a limited part of the Eskimo territories. An American Boy Scout is more likely to have ideas on how to go about it than is the average Eskimo boy of Alaska, Siberia, or Greenland partly because the Scout has read more and partly because he thinks it would be great fun to build a snow house; while the eastern or western Eskimo, if he has heard of snow houses at all, thinks of them as unfashionable and hence inferior.

Eskimo children build play houses of snow throughout nearly the entire Eskimo world but, outside of the dome areas, these are about like the play houses of children anywhere—in Vermont, Montana, or Norway.

Makeshift snow houses, not much better than children's, are made by grown people. For instance, when a hunter of northern Alaska is forced to sleep out, perhaps through losing

his way on a hunt, he builds a coffin-like box. This may be 4 feet wide, 7 feet long, and the walls erected by laying the blocks as if they were sods in the wall of a sod house. Or the blocks may be put on edge, in which case they should be very heavy, say 30 by 20 inches, with a thickness of 8 to 12 inches as against the 4- to 6-inch thickness of blocks used by dome builders. When the walls are high enough, perhaps only 2 or 3 feet, the Alaskan makes an A-roof by leaning together pairs of blocks that stand on opposite walls. The gable ends he fills in roughly, then chinks all crevices with soft snow, cuts a hole in one of the walls big enough to crawl through, shoves in through this hole a block which he is going to use for a door, crawls in himself, closes the door, and makes afterward one or more tiny holes for ventilation.

A chief difficulty of these houses is that they usually get so warm from the occupant's body heat that snow melts on his clothes, making him wet. There are numerous cases of Alaska Eskimos having difficulty in getting home from one of these camps, even during clear weather; for their clothes, being wet, freeze stiff and are difficult to walk in. Besides, wet clothes, if you don't watch them carefully when they are freezing, will wrinkle up, perhaps leaving a bare wrist between sleeve and mitten, or, worse still, the trouser legs may pull out where they meet the socks. Then a wet garment, frozen or not, is less warm than a dry garment.

A type of snow house built in places like northern Alaska has a framework of wood, somewhat as described for earth-and-wood houses. The snow is then used as the earth is used. Such houses are generally made very large, the idea frequently being to pitch a tent inside them, which makes a cosy camp. Practically any kind of tent is good if it is pitched inside one of these barnlike structures.

BUILDING A DOME SNOW HOUSE

There is such infinite variety in the conditions under which snow houses could and should be built, and in the manner and expedients of building them, that nothing but practice leads anywhere near perfection. What should be done is to build a lot of snow houses just for practice, starting under nearly

ideal conditions. When you become skilled you will gradually extend the application of the principles and technique to as much variety of conditions as you can find.

Suitable building snow for dome houses takes a lot of finding even at the right time of year on good terrain.

TIME AND PLACE FOR BUILDING

In the very early fall, while thaws still alternate with frosts, there is seldom any use trying to build a snow house—you then use tents. A little later, when thaws have ceased but temperatures still run as mild as only 10° or 20° below freezing, tents continue preferable and you would not use a snow house except in an extreme emergency. For even the heat from the bodies of the occupants would melt holes in the roof and the snow would be so damp in any case that it would be nearly impossible to keep your clothing dry.

Since the finding of suitable snow if of some difficulty under the best of conditions, it is well when traveling to begin watching for suitable drifts as camp time approaches. It has been the practice of the Stefansson expeditions to camp as much as an hour before the time planned if the party found itself crossing a drift that seemed particularly good. It happened on other occasons that they had to keep traveling for 2 or 3 hours past the intended camp time before finding a suitable bank.

The nearly perfect conditions for snow-house building are: That the terrain shall be level enough to permit strong sweeps of wind, yet with snags or other inequalities that will accumulate drifts 4 feet or more in depth. The winds that made the drift should have been strong rather than violent and the drift should have been made only a few days ago. However, a drift made yesterday by a terrific gale may be just right for house building, though a week or two hence it may have settled into such hardness that building is difficult.

Terrific blasts continued for several days or weeks, with the snow then lying for some time, will make practically the equivalent of ice, so that you have to hack or chop your blocks out of the bank instead of cutting them. They are then heavy,

likely to break, difficult to shape, slippery on the wall, and are such good conductors that the dwelling erected is going to be a poor insulator from the cold.

Under other conditions snow that lies for some time, instead of becoming a solid block of ice becomes a mass of ice granules, the so-called sugar snow, granular snow. In extreme cases you can't cut this snow into blocks at all—it is almost as if you were dealing with a bin of wheat. Under medium conditions, the blocks you cut are fragile. If they are strong enough to handle, and you get your house built, you have a poor one, for not only are the grains icy, and therefore good conductors, but the blocks are also likely to be so overporous that the wind comes right through. This last can be remedied to an extent by heavy outside banking, as described below.

The snows of early winter, except in areas of particularly strong winds, are so soft even in the best drifts that the blocks crumble in handling. When they are just strong enough to handle you can get your house up, but it would soon begin to cave in; for the lower tier of blocks would be compressed gradually by the weight of those higher up. That destroys the dome shape; and when any part of a snow dome changes from its spherical curvature to flat, the next stage is bulging in—which leads to an eventual full cave-in. This process is seldom rapid enough for you to see the motion; but it may be so rapid that views a quarter of an hour apart show a noticeable difference.

The third Stefansson expedition reports taking such chances with soft snow as the following: When a house settled enough during the first 4 hours of occupancy that an inward bulge began to appear, they slept the night and got away 7 or 8 hours later with the sag of the roof still about 3 feet from the floor of what had been a 7-foot house. In practice he sometimes slowed a sag by using a T-shaped post for support where the sag first appeared—a rod with a board across the top. A pillar of snow blocks could have been used.

Building a dome with snow is simpler than with masonry, for stone is intractable and has to be shaped according to mathematical calculation; snow is tractable. Place each

block in its approximate position, lean it gradually against the block that next precedes it, and, by trial and error, snip off piece after piece, or scrape where necessary, until the block settles comfortably into position. (See detailed description of method of building below.)

The equipment needed for building a snow house is: A rod or cane 3 or 4 feet long and one-quarter to, at most, 1 inch in diameter, for testing consistency of snow; a knife with a blade 14 to 20 inches long for cutting blocks, a shovel for piling soft snow on the completed house; a ball of string and two wooden pegs for determining the shape and size of the house when you are new at building—later you will judge by eye.

With four men building, one usually cuts the blocks, a second carries them to the builder, a third (inside the circle) does the building, a fourth (outside the circle) follows the builder to chink crevices. If two men are building, one would work inside the circle and the other outside. In such case a number of blocks would be cut by both and placed inside the intended circle of the house wall before the erection begins. When one man builds, and if the snow permits vertical cutting of blocks (see below), he gets most of the blocks needed from the floor; otherwise he has to crawl out through a temporary door in the wall to get them.

Select a snowbank 4 feet or more deep and of uniform consistency. Determine the surface hardness by your footprints. If the foot (softly shod in Eskimo boot or moccasin) makes no mark, the snow is too hard; if the foot sinks so that its entire outline is visible, the snow is too soft. If you see a faint outline (just enough so that another person could follow your trail), you assume the drift is suitable but you give it a further test.

Drive the testing rod down into the snowbank with a steady shove. If it sinks with even pressure, the snow is the proper consistency. If varying pressure is needed, the snow is in layers and not good, though possibly usable by an expert builder. The novice should whenever possible find nearly perfect snow, for a defective block may bring his nearly finished structure down like a house of cards.

We have described a drift permitting the cutting of ver-

tical blocks, a great convenience especially when the builder has no assistant. If the snow has uniform consistency to four or more inches down but then begins to show stratification, it is still all right for horizontal cutting. In fact, a house can be built of uniform 4-inch snow lying directly on the ground; but then you are likely to be troubled with grass or pebbles, and the blocks are seldom very good.

When you find in one place a drift of suitable depth but unsatisfactory consistency, and shallow snow of better consistency elsewhere, it usually pays to carry the good blocks even 20 or 30 yards to the snowdrift rather than to build a house on shallow snow. If you must build on shallow, your house will have to be of larger diameter than otherwise needed, for it must be of a certain height and must keep to its hemispherical shape.

If you build right on earth, especially if it be on gravel, you must cover every part of the floor with at least 5 inches of snow; for the ground "radiates" cold. Try to see that the snow used for this purpose is not granular—if granular, it permits a draft up from the ground.

Building blocks should be domino-shaped, from 20 to 40 inches long, from 12 to 20 inches wide. If your snow is both tough and light you can have the blocks large. When you first cut blocks they are any thickness from 4 inches up; if the block is too thick you trim it down so that when it is finished it is 4, 5 or 6 inches thick, according to your desire.

According to their size and the density of the snow, the blocks will weigh from fifty to a hundred pounds and must be strong enough to stand not only their own weight when propped up on edge or carried around, but, if they are intended for the lower tiers of the house, must be capable of supporting the weight of 200 to 500 pounds of other blocks resting upon them.

You build the house preferably on a level part of a drift where the snow is three or more feet deep. In any case you either find a level spot or devise some common-sense way of overcoming inequalities or a slope. One way of handling a slope is to build the first tier as described below and then shave it off in such a way that the top of your wall is horizontal. This might mean cutting the blocks down to prac-

tically nothing along the uphill side. It may seem a waste of labor to build a full lower tier just to cut much of it away, but in practice doing so is easiest. Of course, as we shall have frequent occasion to remark or imply, you will be able to modify or even break many of the rules (including this one) when you become really expert.

The first step toward cutting blocks vertically is to dig a pit in your snowbank which, according to your tools and the circumstances, may be of any shape provided one side of it turns out to be straight, of a length equal to the blocks wanted, and as deep as you want them wide. You might keep in mind a block of standard size when cut, say, 36 inches long by 18 inches deep by 4 to 6 inches wide.

To produce your first block you hold the knife vertically and make a cut parallel to and 4 to 6 inches from the side of the straight 36-inch side of the pit, its depth the full length of your knife blade. At both sides of the pit you cut downwards; 18 inches below the surface of the drift you slice with the knife horizontally, undercutting the block.

Now you reinsert the blade of the knife into the lengthwise cut and pry by pulling the handle toward you gently. The block will come out full size and of fairly regular shape, even though in case of a 14-inch knife blade there were 4 inches at the lower side uncut.

You pull the block away to where you can handle it and, if there are any notable roughnesses, you slice them off with the knife. Should a corner break, destroying the rectangular shape of the block, you restore it to rectangular by shortening it that much with a cut of your blade. If the break would necessitate a shortening to less than 20 inches, you discard the block and cut a new one. For, unless you are very skillful, short blocks are more bother than they are worth.

If the blocks are obtained by vertical cutting, it is usually best, when they are placed in the wall of the house, to have uppermost the edge that was the surface of the snowdrift.

When the quality of the drift is not up to vertical block standards, you must cut horizontally. You start with the pit as before, only it need not now be more than 6 or 8 inches deep. The 36-inch cut is now 18 inches away from the face of your pit. When three cuts have described an 18- by 36-

inch quadrangle, you undercut say 6 inches below the drift's surface. This block is not going to come loose as easily as in the vertical case, especially if your knife blade is less than 18 inches long. You therefore move the knife back and forth several times so as to widen the cut, and then very gently you kick with your foot into the cut at various points on the block. Of course, if the snow is really good, one sharp kick will bring the block out. Usually what you have to do with your foot is something like pecking at a block of ice to make it crack along a given line.

When the final kick loosens the block it sinks down a fraction of an inch, because of the undercutting. You now put your knife aside and slip your mittened hands under the edge of the block at points about 8 or 10 inches from either end. If the snow is very fragile, you can help by using one of your feet at the middle of the block so as to have three points of pressure in lifting it up.

When this block, a good deal thicker than you want it and of somewhat irregular shape, is on edge you slice down what was the underside of it until you have the domino shape desired, about 36'' x 18'' x 5 '', if the snow is of good quality but somewhat thicker if it is soft. Houses have been built of snow so fragile that the blocks had to be 8 inches thick. This would be comparatively new-fallen snow which had not been pounded by wind into a sufficiently hard drift and had not had time to settle.

GROUND PLAN

The easiest house to build is circular in ground plan; but for camping purposes a somewhat better shape is oval, the plan being to have the bed platform in the smaller end and the entrance in the larger one.

For a beginner planning to make a house of 10-foot diameter the simple way is to describe a circle with a 5-foot string and two pegs. Even if the house is to be egg-shaped, this is a good way to start, for you have the big end of the house follow the circle approximately.

The larger the diameter of the house the more you promote ease of building by keeping to the circular form. If you in-

tend a house of 15-foot diameter or more, even the most skillful builder is practically forced to conform to a circle. Houses that big are seldom used for dwellings or even for 1-night camps, since they have to be so high that before the lower half of the interior, where the people are, gets warm enough for them the heat has accumulated just below the roof sufficient to melt a hole and escape.

A house of 10-foot diameter is comfortably large for 4 sleepers, snug for 5. You have the bed platform in the small end when the house is oval because you sleep with your heads toward the big end—your body being broader at the shoulders.

When there are more in the party than can be accommodated in a house of 10- or 12-foot diameter, you can either build 2 houses and use them separately or you can build 2 houses right against each other and when they are finished cut a door in the walls between, so as to make a 2-room dwelling. Three- or four-room houses are sometimes constructed in this way. In fact, there is no limit to the extension on cluster principles.

When skillful, you can build one house first and then build the second against it in such a way that if both hemispheres were complete they would intersect to an extent of 2 or 3 feet. Then you build the third house either against the first or second.

SETTING UP THE FIRST BLOCKS

With the finished dome house in your mind's eye, you set the first block on edge as a domino might be on a table. With your knife you then slightly undercut the inner bottom margin so as to make the block lean toward you—at a very small angle if the house is to be a big one; at a greater angle if it is to be small. The second block leans against the end of the first so that a pressure from the outside would not push one over without pushing both over. In similar manner the other blocks are erected until the first circle is complete.

It will be seen that once you have the first block standing on edge it is a simple matter to prop all the other blocks up by leaning one against the other. The nature of snow is such that when a block has been in place for 5 or 10 minutes in

frosty weather it is cemented to its adjoining block and to the snow below at all points of contact and can be moved only by exerting a breaking force.

When the first tier is finished, you can start the second tier any place. From a point three or so blocks away from where you intend to begin the second tier make a diagonal cut, removing the upper quarter of one block, the upper half of the next, and about three-quarters of the third, bringing the cut almost down to ground level. Then take a block of ordinary size and put it in the niche so that its right-hand end rests against the end of the whole block that is next to the right. (The assumption here is that the builder is right-handed. Left-handed you would do these things in reverse.)

Once the second tier is started, build it to the left, leaning each block against the one previously set up, so that the walls rise in a spiral. Since you are building a dome-shaped house, the blocks of the second tier lean in more sharply than those of the first tier.

There is no change in method as the house approaches completion but, of course, the higher up the blocks are the more they lean in. If you lean each carefully against the one set up before it, no block can fall unless one or the other breaks. If the blocks are set up at all carefully and are of passable quality this will never happen.

There will be crevices everywhere between the blocks, some narrow and some wide. These are filled in with soft snow from the outside. It is done gently, for the wall is fragile at first. If the crevice is particularly large, you stick in first a slice of a discarded block and then tamp in soft snow around its edges.

When the wall gets three tiers high it becomes difficult for the man outside to hand blocks in over it. The builder then cuts a hole in the wall and blocks are shoved in to him.

Completing the dome looks difficult. Actually it is easy. If you take two dominoes and place them end to end so that they are nearly in a straight line, you will find it difficult to make them stand by leaning against each other. But the same two dominoes, leaning against each other at a sharp

angle, will stand easily, supporting each other. The like is true of snow blocks—more so, for they meet on comparatively extensive surface while dominoes meet only on corners. Near the roof your circle is small compared with the ground tier. The blocks, therefore, meet at so sharp an angle that you can lean them together pronouncedly. They then support each other well.

When the house is all but completed, the builder finds in the center of the dome above his head a little irregular open space where the blocks do not quite meet. With experienced eye he decides how to enlarge this hole so as to make it big enough for the block he wants to put in it. With his knife he snips off projecting corners and now has above him an opening of regular shape. He next takes up a snow block, trims it so that, for easy handling, it is a little thinner than the average. It is, too, somewhat larger than necessary. This block the builder sets on end and lifts vertically through the hole, so that a person outside can see his two arms sticking up. He now allows the block to take a horizontal position in his hands and lowers it gently down upon the opening so as to cover it like a lid. The block is then trimmed down to size and slips into place.

When all cracks and crevices have been filled, and the builder has, as well, filled in the hole through which blocks were passed to him, the men on the outside throw shovelfuls of soft snow up on the dome. None sticks except what fills the outer part of the crevices that have been chinked, from inside by the builder or from outside by his assistants. Sliding down the sides the soft snow forms an embankment all along the bottom of the wall. Eventually, when the shoveling stops, the snow piled at the bottom makes the walls there perhaps 3 feet thick. Two feet up the banking is only 8 or 10 inches thick. The roof is in thickness only the 4 inches or so of the original blocks.

DOOR

What is to be the final door is made by collaboration of the builder within and his assistants without, and can be at any point except that, usually, it should not be where the

temporary door was. For the original block of the lower tier has there been cut away and replaced, warmly but otherwise inadequately.

Inside an 11-foot house the builder lays off 7 feet for the bed platform. In the remaining 3 feet he digs a trench toward the door, 3 or 4 feet wide and 3 or 4 feet deep (if the drift on which the house stands is that deep). The men outside have dug a matching trench. They know where to dig for the builder has poked his knife out through the wall at a point that is going to be centrally over the door. The door is, then, where the inner and outer trench diggers meet under the wall.

No single block of the ground tier needs to span the trench, for it has taken about an hour to build the house and long before now the various blocks have coalesced so that the house is practically a one-piece structure.

RELATION OF DOOR TO WIND

In a 1-night camp you often have the door to leeward, but for a semipermanent camp it is best to have it at right angles to the prevailing winds. Then at the end of your alleyway you make a turn in the trench, like an elbow joint in a stovepipe, and have this open to leeward. Still more practical is to have a kind of T-joint trench at the end of your alleyway. Then you can open one end and close the other as the winds change, and have an open door to leeward with minimum trouble.

Some Eskimos have the bottom of a snow house door at ground level, not applying those principles of thermodynamics which many of them use in the earth-and-wood houses described *ante*. However, if the camp is to be more than temporary they usually build up inside a platform or bench of snow blocks on which to sleep. This is frequently higher than the top of the door, giving part of the effect you get if you have the entrance by way of a trench.

If you are building a 1-night camp, very likely when the door is finished nothing further is done. But if the weather is bad, or threatening, and particularly if the camp is to be occupied for more than 1 day, a shed will be built over the

trench outside the house. This is so small and therefore so easy to build that no directions for it are needed by men who have been able to erect the main snow house.

The main factor in the control of temperature of snow-house interiors in very cold weather (for reasons given below) is that the top of the door should be at least 18 inches lower than the bed platform, on which the occupants sit or lie. Usually there are about enough broken blocks inside a house when construction ends to build up this platform 6 or 8 inches, which means the top of the door should be at least 12 inches below the surface of the drift on which you build. This is why the drift should be at least 4 feet deep; it is not easy to crawl in through a door which is less than 3 feet high.

If the drift is so shallow that the above ends cannot be attained, and if you want maximum warmth in what amounts to the living quarters of your house, you must build up the bed platform correspondingly. Should this in turn be impossible, you are driven to the expedient of closing the door after the men have all come in, and may even have to open and close it as they go in and out. You use for this closure a block of snow just a little bigger than the door opening and beveled so as to fit snugly.

VENTILATION

Since, no matter how the house is heated, ventilation is necessary, you usually put a ventilating hole in the roof. Its diameter follows conditions of external temperature, abundance of fuel, and whether people are awake or asleep.

By trial you find that, when neither CO nor CO_2 is being generated by a fire, a snow house is adequately ventilated by diffusion if it has been constructed as just indicated and if there is constantly open a door with an aperture of from 5 to 8 square feet. When fuel of any sort is being burned there should be additional ventilation through a hole at the top of the dome. If this is a mere aperture, the escape of warm air melts the snow and gradually enlarges the ventilator. For this reason you should carry a sort of wooden stovepipe to insert in the roof. (Metal does not serve, for the warm air heats it through and that melts the snow which touches the metal.) When no ventilation except from the door is needed, you fill

this chimney with a wad of something or other. With wadding, too, regulate the size of the aperture according to desire. Common practice is to stick two mittens up into the chimney to block it completely, pulling out one or both as ventilation is needed.

When a strong wind blows, gusts of it, and even swirls of snow, will enter through the door unless there is an alleyway as described. With such an alleyway the ventilation through the door is regular irrespective of winds. The cold, fresh air from outside wells up from the door below into the house as fast as, and no faster than, is necessary to replace the warm air passing out through the ventilator at the top.

If the house is of fairly soft snow, no banking is ordinarily thought necessary unless fuel is very scarce or lacking. But if the snow is hard, and particularly if it tends to be granular, then banking is something between moderately helpful and nearly essential. The best way for thorough banking is to erect a tier of average-sized blocks around the house in a circle that is broken only by the doorway. These blocks should lean inward considerably and should be 18 inches or 2 feet away from the house. The space between them and the house is shoveled full of snow; more is shoveled on top of that so the house is banked, but less and less thickly, for a total of 4 or 5 feet up.

Strong winds are rare out on the sea ice, at least when you are more than 50 miles from shore. Nearer shore and on land there are some districts where violent gales may cut your snow walls, largely by a sandblast effect. The danger line is near the ground.

Banking for this protection must naturally be according to circumstances. Perhaps with the pick-axe you carry for making a road through rough ice, or with an ice chisel, you can cut blocks of ice and build something like a stone wall of them to windward; perhaps you can get water and pour over the windward snow banking of your house; perhaps there are pieces of driftwood that can be used, sods, willows, grass that is held in place by something or other. Or you may have a piece of canvas that can be spread over the windward side of the house. (A canvas spread over the top of the dome

may cause too much melting, but there is no corresponding danger for the lower part of the wall.)

PLATFORM INSIDE THE HOUSE

The house is now complete outside, with banking for warmth and protection against cutting winds. You will find on the floor, as we have said, fragments of blocks that were unsound and broke in handling, and other blocks which, for one reason or another, the builder did not use. Out of these you make a platform a foot or so high and covering about two-thirds of the floor space. This is the bed platform which provides your sleeping quarters. It serves to elevate you still further above the top of the door.

Over the bed platform you now spread a layer of caribou or other skins, with the hair side down. The hair side, if snowy, need not be brushed off, for it is against the snow and nothing will thaw; but the skin side, being upward is going to be warm and so must be brushed or wiped clean of all snow. On top of this is placed, hair up, another snow-free skin. Then come sleeping bags or blankets. The two layers of furs are put down not so much to protect you from cold as to protect the snow beneath from heat. The interior of the house is going to be warm presently and people are going to sit around on the bed platform and later are going to sleep on it. If the insulation were not practically complete, heat enough from the cooking and from the bodies would penetrate through the bedding to melt the snow and make the bedclothes wet.

When the temperature of the air outside, and consequently of the snow floor and walls of a newbuilt house, is zero F. or lower, a double layer of deerskins will prevent any thaw underneath the bedding, the snow there remaining as dry as sand in a desert. When the weather is above zero F., or at least when it is above 10° F., you will use tents in place of snowhouses. The procedure for them is described later.

HEATING

When the platform has been covered and the bedding, cooking gear, and other things have been brought in, a fire

is lighted—alcohol lamp, blue-flame (primus) kerosene stove, seal lamp, or whatever. If there is fire enough, it will thaw the walls, but that is what you intend it to do. If fuel allows, bring the temperature up to as high as 80° F.; meantime keep poking roof and walls gently with your fingers to keep track of the process of thawing. This, of course, is most rapid in the roof, for the hot air accumulates against it; usually the lowest tier of blocks, near the floor, does not thaw at all.

GLAZING

The thawing proceeds without dripping, because dry snow is the best sort of blotter and soaks water into itself as fast as it forms. When the inner layer of the roof approaches slushiness and the walls are damp to a less degree, either put out the fire or make a large hole in the roof, or both, and allow the house to freeze. This glazes it inside with a film of ice, giving it strength, with the further advantage that, if you rub against it, scarcely anything will adhere to your clothing. From the dry walls before the glazing you would get your shoulder white at a touch, with a good deal of snow perhaps falling on the bed.

We think of this heating to the slush point and subsequent cooling as mainly to produce an ice glazing; but it has an incidental further benefit. Those snow layers of the dome structure which directly touch the air within the house are no longer of their former intense cold, same as that of the outer air, but now hold a chill which is only a little below the freezing point. Consequently the dome no longer "radiates" into the house the chill that it did formerly. The snow over two-thirds of the floor is still at its outdoors temperature; but it is powerless to chill your room because it is held prisoner underneath the skins that have been spread over the bed platform. The only part of the house that still remains at nearly outdoors temperature and in contact with the air is the floor in front of the bed platform. If this is of gravel, as sometimes occurs when you have to build in a shallow drift on a sand bar, there is a tremendous amount of cold "radi-

ated" upward, so you had better do something about it—at a minimum, spread over it some soft snow. Frozen earth chills the room a good deal more than snow; so does ice if it is very thick.

POSSIBLE MELTING OF ICE FLOORS

But if you build a snow house on ice only a foot or two thick, you may have a reverse situation; then the comparative warmth of the water is conducted through the ice, meeting the comparative warmth of even the floor levels of the house at a temperature that may produce thawing. This you can counteract by spreading snow over the ice, thus protecting it from the warmth of the house; whereupon the warmth of the ocean beneath ceases being adequate to produce melting.

This said melting is of course much more likely to take place on salt ice than on fresh; for, as discussed already, there is likely to be a crust of salt on top of sea ice, and this will turn into brine at temperatures well below the freezing point of fresh water.

The house, when well glazed, is so strong that without taking special care any number of men could climb on top of it. However, it is well to remember that the strength of snow houses is somewhat like that of eggs—they are difficult to cave in with pressure but easy to crack with a blow.

INTERIOR TEMPERATURE

The heating of snowhouse interiors, like ventilation, has a prime relation to gravity. When the temperature outdoors is —50° F. some such temperatures as the following will be recorded within doors when you are burning enough fuel to keep the room as warm as can be done safely—i. e., without danger of melting holes in the roof:

—45° on the floor of the alleyway, just outside the door.

—40° just above the floor and just in front of the edge of the bed platform.

0° on a level with the top of the door.

20° right on the bed platform.

40° at the level of your shoulders when you sit on the platform.

60° just above your head, about a foot below the highest point of the dome.

By mere gravity it ought to be still warmer nearer the dome; but the snow sort of radiates chill, and if you raise the thermometer to within 3 or 4 inches of the snow it may not read quite so high as it would 6 or 8 inches lower down.

The crucial temperature is in the highest air layers, which touch the roof; for they melt the snow unless that effect is checked by penetration of chill from outside. When the weather is —50° and when the highest point of the dome is between 2 and 3 inches thick, with the innermost quarter of an inch ice, a temperature of 60° can be maintained indefinitely without melting.

Temperatures around —50° are rare in the Arctic winter and it is, therefore, rare that you can keep your interior around 60°. Typically you have to be content with 40° or 45° a foot below the dome.

With temperatures from —10° to —40° you usually find that (with the "latent cold" already neutralized, as above) you can keep the full-size door open all night and sleep at a temperature in which it freezes a bit right where you lie. But if you drive a peg into the wall a little above your head and hang a fountain pen from it the ink will probably not be frozen in the morning—which means that the frost during this night has not gone more than a foot or 18 inches above the bed platform.

At temperatures approaching —50° you usually decrease the size of the door opening. The simplest way is to close the aperture with a snow block of the right size, out of which you cut a smaller door—one nevertheless big enough so that by crouching down you can crawl out if necessary. For the door is kept open not merely for ventilation but also in order that you may pass easily and quickly in and out. Sample emergencies which may arise are: A dog fight, which must be stopped immediately to prevent injury to dogs; the approach of a polar bear; break-up of the ice on which you are camped—all of these noises heard through the floor, as described below.

TO PREVENT HOUSE MELTING

If the weather outdoors grows warmer than the temperature in which you made the camp, your body heat may be too great or the cooking heat may raise the temperature high, so that the roof will commence to melt. This is not so much a sign that the house is too warm as that the roof is too thick; so you send a man out with a knife to shave it thinner, perhaps from 4 down to 2 inches, giving the outside cold a chance to penetrate and neutralize the heat from within.

METHODS OF DEALING WITH DRIPPING

We have said that during the thawing which precedes the glazing of a new house the thaw water is soaked up into the dry snow, blotter-fashion. After the freezing has changed this slush to ice a further melting will not result in dripping if the dome is nearly perfect in its curvature and free of downward projections; for the water, instead of dripping, will trickle down the sides. But, as also explained above, the temperature of the house decreases rapidly as you approach the floor. Accordingly, the water, as it trickles, will first reach snow that has not been glazed, producing by congealing there a new, somewhat irregular glazing. If there is enough water so it continues running still farther down, it will either just freeze a certain distance above the floor or else it will trickle all the way down to the snow of the floor, where it will certainly freeze.

Because of this possible trickling, and also because snow might crumble down, the bedding usually should not go nearer the wall than about 6 inches, leaving an open space between.

If unevennesses in the roof produce dripping, in spite of shaving the roof thin as explained above, there are two other remedies. The first and better is to shave or chisel away the unevenness, restoring this part of the roof to an approximately perfect curvature. When that is impossible (as, for instance, when a cave-in has begun) you apply a temporary remedy by providing blocks of snow of shape and size anything between that of a house-building brick and that of a half-pound cake of soap. Press one up against the roof

where it drips. The water will immediately freeze, causing the snow to adhere to the roof. Even without freezing (as in weather near the freezing point) snow will adhere to a wet surface. As water now gathers in toward the dripping point it is soaked by this chunk of snow blotter. You have to keep a watchful eye; when the blocks are soaked nearly to capacity, and are about to drop, you replace them with others.

The snow block blotters are indicated when you know that the house is going to be at an extreme heat for only a little while. For instance, a thaw during cooking will usually stop when the cooking is over.

TO PREVENT HOARFROST

It may happen that the weather turns enough colder than the temperature in which you made camp so that hoarfrost begins to form on the inside of the roof and to drop like snowflakes. On this sign that the roof is too thin, a man goes out with a shovel and spreads on soft snow enough to blanket it suitably.

LIGHTING

One ordinary commercial candle gives more, or better, light in a snowhouse than a 50-candle-power electric bulb would give in a drab room. For the dome is practically a hemisphere of diamonds, every facet reflecting light, multiplying and diffusing it uniformly. This light is comfortable, easy on the eyes. The diffusion is so effective that if the single candle that lights the dome is behind you your body throws only a scarce noticeable shadow on the book you are reading.

When a snowhouse is heavily banked only 2 or 3 feet up and when, therefore, a good part of the dome is only 3 to 6 inches thick, you get enough light from outdoors, even on a densely overcast day, so that there is no need for a candle. You do not, in fact, need a candle for some time after sundown or before sunrise; a full moon in a clear sky will give you enough light for dressing and even for handling cooking utensils (but, of course, not enough for reading). When a house stands on sea or lake ice there may be considerable light in

daytime coming up through the floor in front of the bed platform.

The coming in of light from several or all sides has its drawbacks. The chief is that it may produce snowblindness. Similarly there may be too much light when you are recovering from this eye trouble. In such cases you sometimes throw canvas over the house. This has the disadvantage that it blankets the snow so as to produce melting of the roof from the indoors heat.

WINDOWS

Especially when a snowhouse is intended for long residence, window panes of ice are sometimes used. In addition to admitting more light, these panes have the advantage that they melt less easily than snow, being good conductors of the outside cold. A sample use of an ice window is to furnish bright light where you want it for cooking and at the same time to prevent the cooking apparatus from melting the wall in its immediate vicinity. (We have described in connection with earth-and-wood houses the ways of securing and shaping ice window panes.)

The snowhouse is practically soundproof, most so if the blocks have been cut from new or fairly soft snow; they are increasingly soundproof with heavy banking. The soundproofness is less if a house is unbanked or if the snow it is made of is granular or so hard packed as to approach ice.

But sounds come into a house through the floor. When you are camping on sea ice the crunching of snow under the tread of a polar bear can be heard several hundred yards away if your ear is near the floor. Since polar bears are dangerous to sleeping dogs, and also because their flesh and fat may be needed for food and fuel, sea travelers always have "polar bear on the brain," and with most of them this works while they sleep. A man obsessed either with the fear or the value of bears will hear their tread through deep slumber, apparently farther away than the dogs do. Undoubtedly dogs have better hearing, and their ears are equally near the snow; but they are not as keenly on watch for that particular sound. Doubtless a chief reason why the occupant of a snowhouse hears through the floor is that otherwise the house is

absolutely silent; a dog, out of doors, may be distracted by various noises.

A frequent evidence of the soundproofness of snowhouses and of the transmission of sound through the floor is that when there is a dog fight you hear them spurning the snow and tumbling about but don't hear the growls, barks, and yelps.

That occupants seldom hear through the snowhouse door, although this is usually open, seems to show that the sound is deadened on the principle of mechanical silencers.

One of the great comforts of a snowhouse is that you are not disturbed by a howling gale, so long as it merely howls; but you are instantly disturbed if the ice on which you are camped begins to break up under the stress of wind or current. The sounds of this will come to you through the floor from miles away in the quiet of a snowhouse but cannot be heard a few feet away in the din of a flapping tent. Still the reason you can't hear breaking ice in a tent is partly that the flapping blends with the general roar of ice breakage in such a way that exceptional sounds do not impress you.

A snowhouse settles rapidly if built of soft, new, spongy snow. The other extreme is when you build of snow that has practically turned to ice through lashing by a gale and through long rest in its drift. That material is sometimes chosen if you don't care for warmth and need a house that will stand up a long time, as, for instance, if it is a storehouse or perhaps intended for the sleeping quarters of well-furred dogs that need shelter from the wind rather than warmth. Such structures will stand for months without losing their shape; but even they do settle a bit.

A house settling with intermediate or normal rapidity gets too small for its occupants in 2 to 4 weeks. A dwelling which at first has a clearance of about 2 feet above the heads of the occupants when they sit on the bed platform may have a foot clearance in 3 weeks. By that time, also, the walls have turned to ice and the house is no longer warm. There may have been a few times when a seal oil lamp has smoked or the roof may have been darkened by tobacco smoke, in which case you no longer have the uniform soft effects produced by reflection of candle or seal oil light from crystal surfaces.

For several reasons, then, the house is no longer as good as new, and Eskimos customarily make fresh camps in anything between 2 and 5 weeks.

The process of building the new house, shifting the few belongings of an Eskimo family or of a traveling party, and setting up full housekeeping in the new quarters, need not take more than 3 hours, and seldom takes more than 4.

If you think of the shifting of quarters as equivalent to housecleaning and mentally split up the 4 hours among, say, 20 days, you see that the average time for housekeeping and tidying is not great.

Housekeeping in snowhouses offers many chances for simplification. When you want to hang up something, you drive a peg in the wall. If you want a shelf, you drive in two pegs and put a board on them. If your pillow is not high enough, you just put a block of snow at the right place under the bedding—the bedding insulation will keep an ice pillow from melting, as it does the rest of the snow beneath the skins. If you want to look out, you make a hole in the wall; then you plug it with snow when you are through looking. Similarly, if you want to move some object in or out, you cut a hole in the wall, do your shifting, and then close the aperture with a block of the right size, or with several blocks.

If dogs have no access, you can put down low in front of the bed platform anything you want to freeze and preserve, as, for instance, meat or baked beans. When you want them you just reach down and get them. If dogs have access, you can freeze things similarly and then preserve them safe from dogs and unthawed beneath your bedding. When you throw down into the alleyway anything that is not greasy, you have a perfect disposal. For instance, if it were half a bowlful of oatmeal, you could half an hour later step on it down there in your stocking feet without a sign of stain on your socks, even if they were pure white.

VISIBILITY OF SNOWHOUSE CAMPS

In direct light of sun or moon, a snowhouse is clear to see because of shadows. But when there are no shadows because sunlight is uniformly diffused through an overcast sky, you cannot see one at all unless perhaps if you are

wearing amber glasses. You may walk right into it as you would a snowbank. When moonlight is similarly diffused through clouds, the house, unless lighted, is similarly invisible. But with a candle burning inside, the house will show up in darkness, and to a less extent in moonlight, as a dome glowing softly pink, brightest at the top because it is there thinnest, the light not visible in the lower parts if there is banking. This soft glow is not likely to be visible, however, at more than half a mile or a mile. When there is an ice window the pane is visible considerably farther, probably several miles.

But a snow camp will be visible as a whole in diffused light even when a snowhouse is not. For there practically always is something dark—dogs, sledges, piles of meat, skins that are drying, and so on. Dark things are visible in diffused light at long distances, though not as far as on a clear day.

From the air a snow camp would be visible in diffused light through its dark objects and discolorations. But an airman particularly needs to remember that temporarily, during, or immediately after a heavy and quiet fall of snow, everything may be white, even the dogs sleeping each under his snow blanket. Then a snow camp may well be unobserved when you are passing over it.

A snowhouse may be lined for any of several reasons. At low temperatures the purpose is likeliest to be to make the house warmer or to save fuel. When the temperature outdoors rises toward the freezing point, a lining may be put in to keep the interior heat from melting the roof. If you are afraid of snowblindness, or if you are recovering from it, you would line to secure darkness.

White men sometimes line snowhouses because they are afraid of rubbing against snow. This is really a sign that they do not yet understand how to use a snowhouse, for the blocks cannot crumble on touch after the glazing of the upper part of the dome, and there is seldom occasion to touch the lower part of the wall. Again, white men seem to line snowhouses for psychological reasons—the idea-association of snow and cold is so strong with them that they don't feel comfortable. However, a thermometer will usually serve even better than a lining to convince a tenderfoot

that he is not necessarily cold just because he is close to snow. Stefansson reports that he found it advisable if not necessary to make this demonstration with new men, and Harold Noice says in *With Stefansson in the Arctic* that his own feeling of comfort increased sharply when he had been convinced by the thermometer that the interior of the house was really warm.

ESKIMO CUSTOM

Before whites came, some Eskimos used skins to line snowhouses. Around Coronation Gulf, the heart of the snowhouse district, the principle of using linings was known by hearsay but was seldom if ever applied—then probably only in case of fuel shortage. In Baffin Island, on the contrary, lining appears to have been frequent. The conscious motive was doubtless the increase of warmth rather than the saving of fuel, for temperatures of from 80° to 100° were desired as an accompaniment to sitting naked. (Coronation Gulf people usually were dressed in their unlined snowhouses, although they sometimes sat stripped to the waist upon the bed platform, the children sometimes playing on the furs completely naked.)

GLAZING PREFERABLE

It is desirable that a lined snowhouse, like any other, should be glazed. As already stated or implied, a snowhouse that has just been built from blocks of medium hardness would crumble under the weight of a child. When, however, over the upper half of the dome the inner portions of each block have first been allowed to freeze, the resulting eggshell of glazing makes the house so strong that, although the lower tiers are still nothing but snow, the structure as a whole will nevertheless support several men and probably would support about as many as could stand on it. Dogs at play on occasion break down an unglazed house, though when it has been set with glazing a thousand-pound polar bear would not break through by merely scrambling over. There are, in fact, numerous records of polar bears climbing upon glazed houses but few, if any, accounts of the houses having broken. What does break them are sharp blows, as when a man stamps with his

heel. A bear will gash a roof with a scratching blow from his forepaw.

CLOTH LINING PREFERRED

When cloth lining is available, it is preferable to skins. It should be both thin and nearly airproof. It could be cut and sewed into dome shape but seldom is, for then it would fit only one size of house. Ordinarily you have a piece that is square, or even irregular, in shape, with tie strings sewed or otherwise fastened in numerous places.

METHOD OF LINING

If the house is strong enough, as when glazed, a man climbs up on it outside, sticks a knife down through and makes a hole say 2 inches in diameter. Someone inside then shoves up through the hole the central tie string of the cloth. The man outside ties this to the middle of a cross-piece of wood so that the cloth hangs an inch or two below the snow roof. He then fills in the hole around the string with snow. Similar arrangements are made at other points of the dome until the cloth is suspended so as to be on the average 2 or 3 inches from the snow everywhere—perhaps a little more at the lower parts of the wall where it hangs slack.

If, for want of fuel, you are unable to glaze a snowhouse, the whole job of suspending the lining is done from inside. The operator makes holes in the dome from inside, pushes out the tie strings with their cross sticks, and fills the holes by tamping with soft snow from inside.

VENTILATION

There is usually a hole in the cloth corresponding to the ventilator hole in the snow dome. Because the cloth has been suspended from the center, the ventilator is usually a little off center in a lined house.

c. Tents

CHOICE OF TENT CAMP SITES

It is everywhere important to choose house sites carefully; in the Arctic this is doubly important with tents, for reasons which will appear. We therefore discuss under Tents the

general subject of camp location, referring mainly to winds and their effects, for these are the chief foes of comfort, convenience, and safety.

In matters other than winds and their effect, temperate zone experience, and forethought based on it, are in the main suitable guides for Arctic camp location.

DO NOT CAMP IN A LEE

The first instinct of Europeans when they go to cold lands is to build or camp in a shelter. But lees gather snow in an open country. You should not build a house in a lee, for it may get covered and that will be a nuisance. You must not pitch a tent in a lee, for, weaker than a house, it collapses under the pressure when snow buries it. Well before collapse the snow covering may bring serious results. Carbon dioxide gathers through decrease in ventilation so that lamps will not burn and breathing grows difficult; carbon monoxide may gather, and then there can be tragedy. (For further discussion of monoxide poisoning, see Chapter 10.)

LONG HISTORY OF MONOXIDE TROUBLES

There is a series of recorded difficulties with carbon monoxide from the Barents expedition of 1596 to the Byrd expedition of 1929. In a good percentage of the cases the trouble was in one way or another connected with tents or camps becoming snow-covered because of a lee. Three out of four of the Andrée expedition of 1898 died of monoxide poisoning, apparently because they had camped in a lee.[6] Their bodies were discovered in 1930.

A white man's desire for what might be called natural protection for his camp sometimes takes very special forms. The 1933–34 expedition which the U. S. S. R. sent out on the *Chelyuskin*, under Professor Otto Schmidt, consisted of a hand-picked personnel. Yet on page 142 of *The Voyage of the Chelyuskin*, New York and London, 1935, we find:

"* * * A number of tents * * * were let down a good meter into the ice so as to present less area to the wind.

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[6] For causes of deaths in the Andrée party, see Stefansson, *Unsolved Mysteries of the Arctic*, New York, 1939.

As soon as the cold decreased a little, water began to soak into the pit and swamp it. Those 'experimental' tents had to be completely rebuilt in another place."

By this procedure the ice found itself between two warmths—from below the warmth of the unfrozen sea and from above the heat of the tent's interior. Therefore it melted. You can never safely use ice or snow for wall, floor, or roof except when inner heat is counterweighed by outer cold.

If in winter a camp is on land in —50° weather, the snow in the floor is at first —50° and the earth just below —50° at the surface, though it gets less cold gradually as you go down. The sea water below the *Chelyuskin* tents was at 27° or 28° F. Under such conditions you should camp on ice as thick as possible, to get away from the comparative warmth of the water. You should, if you can, have snow on your floor for further insulation. You should build up a platform of snow (skin-covered, as in a snowhouse) to sit on so that you may be sufficiently warm up there without having it get so warm lower down that the floor tends to melt. In fact, you should keep a specially watchful eye on the laws of physics when you camp on sea ice that is only a few feet thick.

IN A FOREST

Naturally in a forest you always pitch camp in a lee, for in woods the snow does not pile up by drifting. It would be silly to hunt for an open space and pitch camp there just to fit in with principles that apply in treeless country.

IN MOUNTAINOUS COUNTRY

Where you are a stranger, a forest, then, or very extensive patch of willows is the only terrain where you would camp in a lee. But if you know the country, you can sometimes find lees extensive enough to be safe among hills or mountains.

Strong winds passing overhead, giving you an extensive lee near a mountain, are reported chiefly from Greenland but are not unknown in northwestern Alaska back of Cape Lisburne, and may be found, no doubt, here and there in all mountainous areas. The difficulty is you seldom can tell in the summer that there is going to be a safe lee in a given

place the following winter. In midwinter you can, of course, determine it from the character of the snow which already lies on the ground.

In mechanics this overhead lee resembles the dry space behind certain waterfalls, due to the water having such speed that it shoots over the edge of the cliff and descends in a curve. A wind from inland blowing 50 miles per hour might not strike the ground for one or even several miles after passing the edge of a cliff or very steep slope that is a mile high.

HOW CAMPS GET BURIED

In a forest or any other big lee you can leave sledges, baggages, etc., to windward of your camp; but you cannot safely do so if the tent is in the open, for these obstructions will produce their own lee, forming drifts to and upon the tent. Neither should things be left in the lee of the tent, for they will get covered up.

No obstruction can produce in any one storm a snowdrift deeper than its own height, so that it does not matter for a single night's camp if the tent is in the lee of your sledge; but it does matter a whole lot whether the sledge, being lower, is in the lee of the tent—it may get so deeply buried that you will have difficulty in digging it out next morning. But if you are going to live in a tent for several weeks, the sledge, which has doubtless been moved meantime, will produce in the second blizzard another drift of the same height as the first, though perhaps at a different angle. Eventually various drifts from various obstructions will be so superimposed that your whole camp site is a hill in which your tent gets buried. In short, if a camp is to be occupied several weeks, and if you are not in a "trade wind" area, you should see to it if possible that no drifts at all are formed near enough to the tent to start the burial process.

WHERE WINDS ARE REGULAR

There are places where winds of only a few directions occur, behaving almost like trade winds though usually locally produced by land configuration. Stefansson reports a coast, the north Alaska shore from Barrow, or at least from the Colville, to near the International Boundary, where for several

score miles only three winds occurred that were strong enough to form bad snowdrifts—S. W., N. E., and E. N. E. In that district they felt free to leave a sledge standing only a few yards from the tent if it was to the northwest or southeast of it. Similarly, two or more houses or tents could there stand close together without danger of getting each other covered up by snowdrifts, if they were placed approximately on a N. W.-S. E. line.

CONTROLLING DRIFTS

An example of the possible great commercial or military importance of realizing that any obstruction will produce a snowdrift in its lee was furnished during the construction of the Hudson Bay Railway through the last one or two hundred miles before reaching Churchill. The first winter of building, the crews of men cleared the track after a storm by shoveling in both directions, thus making a trench which had the railway track at its bottom. In the next storm the trench filled level with the windward embankment, whereupon the track was shoveled clear again, heightening each embankment. Before spring the track was buried so deep on the open prairie that a freight train passing between the ramparts was nearly invisible from a distance. This method of snow shoveling cost thousands of extra dollars in wages and slowed up construction to an extent for which the wages were not an adequate measure.

Next winter the work and expense were reduced to a small fraction. The engineers had noted that all the strong, and therefore drift-forming, winds were from one direction. Accordingly, such snow as gathered on the track was always shoveled off to leeward. The snowdrift produced by that rampart was directed away from instead of across the track.

WINDBREAKS FOR TENTS

If you pitch your tent on an open prairie, it can have, and in most cases should have, a windbreak of snow blocks. It is windbreaks at intermediate distances that bury a camp; those far enough or close enough protect it. A far windbreak is usually beyond one's resources—it has to be something as

big and effective as a range of hills or low mountains. A windbreak right up against a tent is therefore indicated.

If it is a one-night camp, a tent should, then, be protected by a wall of snow or ice blocks that forms a segment of a circle to windward, and a few feet away. Even a wall only 2 feet high is of considerable value for a 7-foot tent. A 5-foot windbreak for a 7-foot tent is about all that is worth building, for it matters hardly at all even in the most violent gale if the peak of your tent is exposed to the wind, so long as the sides and bottom of the tent are not exposed.

MANNER OF BUILDING

A windbreak wall can be built after European sod-wall fashion; but, if the campers have the necessary skill, it is usually much quicker, and is in some other ways better, to build Eskimo-style, curving in just enough so that the wall segment will stand on dome principles. In such case the windbreak is just far enough from your tent so that a man can work comfortably between.

FOR PERMANENT CAMP

If you are going to spend several days, or think there is danger of the wind changing direction in the night, you might build a windbreak in a circle completely around the tent.

Usually such things as building windbreaks are not a waste of time. For instance, after six men have cooperated in the pitching of the tent, two would be occupied with cooking, two staking out and feeding dogs, while the remaining two could build the windbreak and have it done by the time the others finish their jobs. Besides, activity is sometimes necessary for keeping warm.

REINFORCED WINDBREAKS

If you think that a particularly violent gale may come up (for instance, if you are encamped in a known "blow hole"), it might be well, if water can be obtained, to pour a few bucketsful over the windbreak wall, whether this is made of snow blocks or of ice. In the case of snow blocks this watering is not to hold them together—they will stick to each other anyhow. It is to make a glazing on the windward side of the

snow so that the gale shall not cut it away. In winds of 50 to 70 m. p. h. even fairly hard snow blocks are gradually cut, perhaps not so much by the wind itself as by drifting grains of snow acting in the manner of a sand blast.

Another way of protecting a snow wall from breaking is to cover the windward side with some fabric, or with skins.

TENTS, GENERAL

While the warmth of a tent, like that of clothes, depends on air spaces, it is not practical with fabric tents to have enough of these air spaces within the fabrics themselves. The equivalent must be obtained by using a double tent.

Skin tents, like skin garments, derive their warmth largely from air spaces, those between the hairs where the fur is so twined that the interstices amount to nearly the same as air cells. Or, as in the case of caribou, the warmth is partly secured on the above fur principle and partly through the hairs themselves being hollow and filled with air.

However, even with skin, it is frequently advisable to have a double covering so as to get a layer of air, say an inch thick, to separate the outer and inner covers. This is easily attained with furs—place the fur sides toward each other and the hairs hold the skins apart. To keep an air space between two cloth covers you stretch the tent tightly so that bagging shall not obliterate the space, or else you have to stuff something, as grass or feathers, in between the layers.

With skin tents it is usually best in summer (when you need only one layer) to keep the hair side out. The same is true in winter when you have only a single layer; but if you have two layers the hair is out on your inner covering and in on the outer.

SHAPE OF TENT

To save material and economize on heat, there should be little waste space in a tent. This means that a tipi form, or any with a sharp peak, is undesirable—the peak requires extra material and greatly increases the necessary fuel consumption in that the warmest air gathers where occupants get no direct use from it. If your tent does have a peak,

however, you can get some indirect use by hanging there things that need drying. This by no means justifies the peak, for a dome-shaped tent (most economical because of the law of spheres) is so much more easily kept warm that garments will dry better suspended from its roof than from the peak of a tipi or A-shaped tent.

Translucence of a tent promotes interior warmth when there is sunshine; it enables you to utilize daylight; even at night you can make indoor use of moonlight and other natural night light. You can light the interior from a bonfire which is near it outside. A white tent is least easily detected on snow background, but this is rarely of much value, even when you want to hide, for there are likely to be many dark, easily visible objects around, such as dogs, sledges, people. A disadvantage is that in a translucent tent you must bandage your eyes when trying to make a quick recovery from snow blindness. Indeed, snow blindness may develop inside the tent—a person whose eyes are in perfect condition at the beginning of a 3-day blizzard has, in more than one reported case, become snow-blind on the second or third day of confinement. Snow blindness may come on, or be aggravated, during sleep; so that it may be advisable, even for those whose eyes are perfectly well, to sleep with them bandaged. Whenever awake during the day, and if you have reason to fear snow blindness, you would in a translucent tent, or in a snow house, use amber glasses as if you were out of doors.

OPAQUE TENTS

A dark tent cuts down the utilization of outdoor light, naturally. Its chief advantage is that it prevents snow blindness from developing indoors and helps to cure that which has resulted from out-of-doors exposure.

TENT FORMS

There are current numerous bright ideas which work badly, indifferently, or at least have drawbacks not ordinarily mentioned by their proponents. For instance, the door which ties shut like the mouth of a dufflebag works only while the material is either not frozen or else frozen and dry. When

moisture gets in at below-zero temperatures, which is soon, the mouth of the bag becomes increasingly difficult to tie, and finally impossible. That you do not find more accounts of this trouble in the books of explorers is mainly for the reason which Peary gave frankly—that the things he had learned from experience were trade secrets and should be kept for his own advantage or that of the country and flag he represented. Other travelers have been reluctant to describe defects of equipment because the inventions were their own, those of friends, or of famous men whom they did not want to seem to criticize.

ONE-PIECE FLOORED TENTS

An idea usually found in connection with the dufflebag door is having a floor sewed into one piece with the rest of the tent, the theory being that the snow cannot then get in. The troubles with this are numerous. You don't always succeed in brushing from your clothes all snow before crawling in through the door; a swish of wind may bring in snow while you are entering; moisture from the breath will condense on the roof and sides of the tent, to drop practically in the form of snow. Some of the snow, however it enters, will get under you when you sit down or lie down. Then it melts and turns to ice which permeates or clings to the flooring.

If one has a floor, it should be separate from the rest of the tent.

MONOXIDE DANGER

An aggravated danger of the completely enclosed tent—an attached floor and a dufflebag door—is that of monoxide poisoning, which we discuss elsewhere. For if a tent is capable of being made airtight you are likely to take a chance on making it so when you feel very cold, or you may by accident close the door tighter than intended.

The conical tent with central pole is in most places easiest to pitch and it stands up pretty well, but not nearly so well as the hexagonal or octagonal tent with bamboo ribs hereafter described.

Bell tents, wall and center pole, are not so very hard to pitch. For special method of pitching see below.

The A-tent is undesirable in windy weather, for the rectangular surfaces will belly in and hold wind like the square sails of a ship, making a terrific strain in case of a gale.

An A-tent with walls is worse for stormy countries than the simple A-tent in that the wind catches still more, and holds.

UMBRELLA TENT

Perhaps on the whole the most successful European invention of a tent for windy and cold countries is the umbrella type. These are in shape cones of four, six, or eight sides, constructed on the umbrella principle as to ribs, these, however, being straight, unbendable, of bamboo. Such four-sided tents were used by the British in the Antarctic and by some others. But each side of a four-sided tent is so big that it bellies in before a strong wind and the tent is likely to blow away or break down. Six bamboo ribs are, on the whole, most advantageous—one-sixth of the circumference is then the most that fully bellies in to hold the wind. The two adjoining sectors, though bellying in somewhat, nevertheless spill the wind. Eight sides would be best of all if it were not that you then have a larger bundle to carry on your sledge.

The only structural problem with this tent is to devise a good cap into which the upper ends of the ribs fit at the apex. So far as I know, this detail has never been satisfactorily handled by a polar expedition. It is, therefore, a problem that should be tackled in a laboratory manner.

The four-, six-, or eight-sided umbrella tent is made double by having a slightly smaller tent of the same construction suspended from the inside. It is tied to each rib with tape at two or three points between floor and apex, and, of course, the apex fastened similarly. This gives, when the tent is well stretched, an air space of about 1 inch everywhere. The space will lessen somewhat, or may disappear, when the tent bellies in under a strong wind; but it disappears at most only for a portion of two of the sides of a four-sided tent (if the wind blows right on a corner) and correspondingly for tents of six or eight sides.

The outer covering of a double-fabric tent should be windproof. There is some question as to whether the inner cover-

ing, or lining, should be similarly wind proofed. Probably it should. However, there is force in the argument that if the inner tent lets air through easily, then a considerable part of the steam from cooking and from the breath of the occupants will pass through and condense between the two tents. Then the hoarfrost dislodged by flapping will not fall on the beds but will slide down to ground level between the two coverings.

The best material which Stefansson has actually tried for a double tent is Burberry. This used to be a great deal better than any form of silk on the market, no matter how treated. There may have been developments since that would give a material surpassing Burberry. But no material will work which depends for windproofing on some such filler as paraffin, which at low temperatures makes the fabric stiff. Paraffin also cracks, especially at low temperatures, and drops out where the fabric bends.

EASY TO CARRY

The straight-ribbed type of tent folds into a long bundle and carries well on top of a sledge. The corresponding Eskimo invention, below, does not transport so well; but in most other respects it is better.

The Eskimo dome tent has little except portability to distinguish it from the Eskimo dome house already described. We add here, therefore, only a few points.

The dome house was assumed in our description to have a frame of willows that were of local growth. They might be somewhat crooked and they might be heavy and knotted. But tent framing which you are going to carry with you should be of slender, sapling willows, if you depend on Arctic materials. If you bring the material with you, as on a ship, it could well be of steamed hickory or other pliable and strong wood.

ROOF

In the house description we rather insisted that the shape be approximately hemispherical, for then a frame of minimum strength supports a reasonably heavy roof. In a tent you are going to have only light roofing and the willows can, there-

fore, be not only slender but also bent in a way that produces marked wall curvature and a roof that may be nearly flat, especially if the tent is large. A strictly hemispherical tent would always have to be of the same size; you can vary the size if the willows are bent for the walls and straight, or nearly so, for the roof.

One great advantage of this type of tent is that in emergencies you can make it of several small pieces of cloth—torn sail, for example. As said, you can make it practically any size—if you want it large, you lash the hoops so they overlap very little; if you want it small, you have them overlap a lot. Eskimos sometimes carry a cover sewn in just the right size and shape to fit the frame when put up in a set way. That probably is a new adaptation—either borrowed from whites or a result of using cloth in place of skins.

POSSIBLE NEW STYLE TENT

The best two tents ever developed for cold weather are the dome-Eskimo and the straight-ribbed-umbrella type worked out by the British Antarctic explorers. It seems possible that our ingenuity and range of materials might enable us to develop a new tent combining the two ideas into a form superior to either. Suggestions are:

A tent might be made strictly like our umbrellas. The umbrella handle would then be the center pole of the tent, the ribs would hold it out into hemispherical shape, and the braces would not be useless, since you could put things up there to dry. Obvious difficulties are that, if the ribs were of steel, they might lose their resilience at very low temperatures—might break in bending—and that steel, in any case, is heavy. More hopeful, it seems, would be to find some wood like hickory which, perhaps through some form of reinforcing, would bend just right each time the tent is put up and would straighten out again for packing.

Another possibility is that curved ribs must be carried loose on the sledge during the day, as willows are by the Eskimos, and fitted in at camp time. They could then have the required curvature but would, of course, be unhandy on the sledge, as the Eskimo bent willows always are.

The Eskimo dome tent dispenses wholly with guy ropes; the British Antarctic straight-rib-umbrella type does also. Guy ropes would, therefore, probably be unnecessary, unless when in fear of a terrific gale you might want to run one rope to windward from the peak.

PITCHING TENTS OF VARIOUS TYPES ON ICE

On glare ice, the worst of all locations for a tent, it can be fastened down by any number of devices, each suggested by conditions. In extreme emergencies you can freeze down the edges by getting water through a hole in the ice a little distance off and sloshing it on to the edges of the tent, holding them down during the freezing. The difficulty is that when you break camp it is hard to avoid tearing the tent or carrying off with it (when you chop it loose) a considerable weight of ice.

ANCHORING WITH ICE OR SNOW

When ice is thin, you can cut through it, as when a New Englander puts up in winter ice intended for summer use. Blocks so obtained can then be put on the edge of the tent to weigh it down, the ice beneath previously roughened so as to give the weighting blocks a chance to hold. Perhaps an actual trench will need to be dug.

When snow is available, you first put enough blocks of it on the edges of the tent to hold it temporarily. Then you shovel up some loose snow for additional weight and to cement the blocks together. When you have enough weight on the tent flaps you pull them outward (with the snow load on them) till the tent is set to your liking.

If snow has a chance to set for half an hour during cold weather it becomes almost as hard as concrete and will hold the tent if a storm blows up later. If the storm is already blowing when the tent is being pitched, the same principles apply, though the pitching is more difficult. One or two men may have to hold the windward side of the tent while the snow is being piled on and for some time thereafter. Often the holding up is best done from the inside.

When you have a sledge, you can tuck the windward edge of the tent under one of its runners, weighting the sledge

down, if necessary, with blocks of snow. It is explained elsewhere that a sledge must not be left to the windward of a tent, but this refers to one at a moderate distance. A sledge standing right on the edge of a tent will hardly accumulate a snowdrift.

TOGGLES FOR BELL AND OTHER TENTS

With a bell or other such tent, on glare ice, there would be a wooden or other toggle at the end of each guy rope. Dig a circular trench in the ice at a considerable distance from the tent or dig a separate hole for each guy rope; put the toggle, at right angles, down into the hole or trench and pack in snow if a little is available, or finely chopped ice; perhaps pour on a little water, if that seems necessary. If the tent is pitched on snow, the toggles would be buried in the snow and tamped down—as said, such packed snow sets in the manner of concrete, not, of course, nearly so hard but usually hard enough to hold a rope in a gale if the toggle is, say, the length of a policeman's billy and strong enough. The wall is banked and otherwise fastened down in the manner of a single cone tent.

One of the best ways to fasten the end of a tent rope on ice is by "ice toggles." You cut parallel trenches (with ice pick, pickaxe, hatchet, or whatever) 3 or 4 inches apart and 6 or 8 inches deep. Perforate the dividing wall, pass a rope through, and tie.

A tent has to be carried on the sledge but the snow awaits you at camp time. Over rough sea ice, the bulk of a load is sometimes more serious than its weight, and even a dry tent has some bulk. When ice from the breath of the occupants, cooking, etc., gathers in a tent through use, it not only becomes heavier but also stiffer and therefore bulkier.[7] The tools you need for building a snow house are, practically speak-

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[7] This is, of course, a comparison of tents with unlined snowhouses. However, a lining does not necessarily accumulate ice; in cold weather a tent inevitably does, unless you can superheat it and thus dry it occasionally (which practically means having a wood stove and plenty of dry wood to burn).

Nares, in his *Voyage to the Polar Sea,* states that his tent weighed 31 lbs. 14 oz. before starting and 55 lbs. on return. In his *Farthest North,* Nansen gives a similar result for his long sledge journey.

ing, none. For your snow knives are used for other purposes and your shovel is also a tool of general utility—you want it as badly for a tent as for a snowhouse.

While it takes longer to build a snowhouse than to pitch a tent, this is partly cancelled next morning; for you have to pack up a tent and load it on your sled, but you just walk away from a snow house.

When your breath and the steam from cooking rise to the roof of a snowhouse, they congeal and stay. In a tent they rise to the roof and congeal but do not long remain, for the flapping of even a slight wind will dislodge flakes that flutter down upon bedding and clothes, eventually melting. Not even in a perfect calm are you free from this snowfall; the flakes will loosen and begin to drop when the hoarfrost on the roof gets thick enough. However, some of your breath and the other moisture will remain on or in the tent fabric as icing.

While it takes a good deal of heat for an hour or more to neutralize the cold of snow walls at low temperatures, you do not thereafter need any heat except that from the occupants to keep a snow house comfortably warm; the temperatures, at least toward the roof, will continue to run well above freezing indefinitely. A tent, on the other hand, heats quickly when you light a fire but cools as quickly when the fire goes out. It has been found in an ordinary single wall tent of, say, 10-ounce duck, that when the temperature at night is $-50°$ outside it is likely to be $-10°$ or $-20°$ indoors.

DRYING CLOTHES

Because snowhouses stay warm, you can dry wet clothes in them to some extent by merely hanging them up, and better by wearing them. In a tent you can similarly dry clothes while the fire is going. Clothes dried in snowhouses stay dry; if dried in tents, say during the cooking, they are likely to get wet again in the night. For instance, you might, in either snow house or tent, dry a wet sleeping bag by crawling into it. After the fire goes out the drying process would continue in a snow house; for, as said, the room is warm. But a tent gets so cold that hoarfrost would begin to gather in the bag; probably it would be at least as wet again next morning.

In good weather both tents and snowhouses are quiet. In a storm a tent (with the partial exception of the umbrella tent) makes a racket through flapping. A snowhouse in a gale is not only immobile but completely silent except, as mentioned, for sounds that may be transmitted through the floor and for the soft buzzing of granular snow that drifts over the roof.

VENTILATION

There is temptation for bad ventilation in a tent—you close up everything for warmth. When ice fills the pores of the cloth, and if the tent is well banked, you court monoxide poisoning. With a snowhouse there is every inducement to good ventilation—the building is designed for it and is comfortably warm even when well ventilated. (See chapter 10 for discussion of monoxide poisoning.)

Lights and cooking apparatus work better in a snowhouse. The flapping of a tent makes a primus or other flame flicker, reducing effectiveness and perhaps making smoke and soot. A candle gutters in a tent but burns decorously in a snowhouse. Besides, as explained, one candle will give more light in a snow dome than several even in a white tent—and a tent never stays white very long.

Those who have camped in tents have memories of inconvenience and discomfort, except, of course, under conditions where you burn in suitable equipment all the fuel you want. To snow camps the traveler looks back with memories of quiet, cosy well-being. This is even true where no fuel is available that can be satisfactorily burned in a snowhouse. For instance, David Hanbury tells in his *Sport and Travel in the Northland of Canada* that, although the midwinter temperature of the snowhouses near Back's River were always below freezing, and sometimes below zero, the occupants were nevertheless comfortable. Doubtless Hanbury's saying this harks back to his memories of tent camping among the forest Indians of the Bear and Slave Lake districts.

WINTER TENTS

For camping in a northern forest during summer practically any standard tent is suitable, if you remember that

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special devices have to be used against mosquitoes and sandflies—you have to have tents that close tight except where there are windows or ventilating devices of fly netting.

Also for winter camping in a forest tents of standard make are suitable, with few exceptions. They should not be particularly high, for it is wasteful to heat air within a tent higher up than the occupant reaches when standing erect.

USE OF DOUBLE TENTS

Because there is little wind in a forest, you find it easy there to apply the air space principle. Take, for instance, two A-tents, or two of these with walls added. Have one of them slightly smaller than the other, the smaller being suspended from the ridge pole of the bigger and being inside the uprights that support each end of the larger tent's ridge pole. The two tents are then fastened together by tapes that are at all points where there are guy ropes on the outer tent. You then have a double structure, with an air space three or four inches, that heats up so readily that the fire in your camp stove is no more than well started when the interior is as warm as anybody wants it to be.

CONTROL OF HOARFROST

For a winter camp it is probably not worth while to use special material—drilling or light canvas will do very well. During the day, or whenever the fire is going, no hoarfrost will form inside the inner tent. A tremendous amount of hoarfrost will form in the space between the two tents; but that does not do any harm. If so much forms that you begin to notice the inner tent sagging under the weight, then you just slap the bulge with your hand and the frost, now the equivalent of snow, will slide down to the ground in between the two tents. A little rime may form on the inside of your inner tent during the night, when the fire is out, but not enough to cause serious inconvenience. For if a little does drop on the bedding, the tent is going to be so warm the next morning, as soon as the campfire is started, that any dampness will soon dry away.

DANGER FROM SPARKS

For a camp in a forest one percaution is crucial, although no more than of slight importance on the prairie. You must guard the tent against sparks from the stovepipe. You do this with a cap of wire gauze that you put on top of your stovepipe.

On the prairie there is nearly always a breeze, and sparks will be carried clear of the tent; however, in a very calm night you are likely to burn holes in your tent roof, even on a sea coast. In a forest you would have holes within a few hours, if not within a few minutes, unless precautions were taken.

It may be practical to fireproof the material out of which are made tents intended for winter camping, whether in a forest or on a prairie where firewood is abundant. Then you would not have to bother with a wire gauze cap for your stovepipe.

WINTER FOREST CAMPS

For northern emergency housing we have discussed types suitable to forest, to prairie, and to sea or lake ice. Tents we have discussed thus far only with reference to prairie and to ice, except that the dome Eskimo tent has been treated as a marginal forest-prairie type. We now discuss the two main camping methods that are used by the Indians of the northerly spruce forest, the tipi (tepee, teepee), and the open camp.

TIPI CAMPS

The tipi sort of winter camp used by the forest Indians just south of the Eskimos in Canada is one sign of the profound adaptational differences between these two peoples. The Eskimos—in their clothing, housing, and use of fuel—have come so near perfection that even those white men who have lived among them many years have succeeded only in making negligible improvements; the winter use of the tipi, common though not universal in the northern edge of the forest, is an example of flying almost directly in the face of nature.

ERECTING THE TIPI

You start the northern tipi by cutting down a number of slender spruce trees, 10 to 14 feet long. You fasten two of these together a foot or two below their tops by a rope, withe, or strip of bark so that they make a crotch; you lean a third into this crotch, the three having their butts standing in what is going to be the circular base of the tent. Hereafter you lean more and more poles up against this tripod, until with 10, 12, 14, or more, according to the size of the tent, you have a complete circle (cone). Next you wrap a big robe of skins or big piece of canvas around the tent so that it overlaps considerably; but you leave a wide opening at the top.

During summer, when this type of camp is unexcelled, you see that none of the tent covering touches the ground—either you have a clear air space all around or you pile brush so that the lower margin of your robe or canvas rests on a pile of twigs instead of on the ground, the air then filtering in through the brush. You start your fire and this creates such a draft all around that even on a hot day it is not uncomfortable to sit in a tipi around a big fire. The front of your body may be overheated but there is a cool current up your back. And one of the best points is that the draft sucks in mosquitoes and sends them up with the smoke—likely scorched but at any rate expelled.

In winter no arrangement could be much worse than this. At a minimum you will need a draft coming in under the tent edge at three places, equal distance from each other, otherwise the tent fills with smoke. Let us say the temperature outside is 60° or 70° below zero, and that may well be in the northern forest, where the lowest known temperatures of earth are registered. If the blaze indoors produces a high temperature there is a reinforcement of the summer draft mechanism; because of the now more pronounced gravitational differences between the outer and inner air, the draft is much accentuated. You are then in a position where, if dressed in wool, you feel instantly an insistent chill on your back when the front of your body is scorched by the fire. If you turn around, with your back to the flame,

you can see hoarfrost forming on the front of your coat and trousers. If you hang up a wet pair of woolen mittens they will dry on one side while hoarfrost develops on the other; turn them around, and while the hoarfrost is melting a similar rime will form on the side that was recently dried. If fur clothes are worn you do not have quite the trouble with rime but you are likely to injure your garments by scorching them.

It is not quite impossible, however, to dry wet garments in a tipi camp. For instance, a mitten of cotton or wool, of any material not readily spoiled by scorching, may be fastened to a board which you stick up at a suitable distance from the source of heat. That way you can dry one side without hoarfrosting the other. The first side dry, you turn the mitten over; when that side has dried you put the garment somewhere away from the heat—under your bedding or out of doors.

Damp clothes will dry on your body if you wear them in a tipi near the fire, except for the outer layers. This means that if you have three or four layers of woolen cloth you can dry all of them on that side which faces the fire and all but the outer one or two on the side away from the fire. For while the fire is going the air in the tipi is a good deal warmer than out of doors except just in the three or four places where it enters under the tent flaps.

In the Great Bear Lake woods it is common during midwinter that two men sitting 3 or 4 feet apart cannot see each other for the steam that is being created by the mingling of the intensely cold outer air with the air heated by the fire.

When bedtime comes in a winter tipi camp you are in a dilemma. If you keep the fire going you also keep going the intense draft. If you let the fire die down the warmth of the earth on which it was burning will continue to heat the air, continuing the draft to a point where the interior of the tent is practically as cold as outside. This will mean 50° below zero inside if it is 60° below zero outside.

The above may seem exaggerated; but it is really an incomplete and inadequate description of the discomforts of a tipi camp. Therefore it is the preference of many whites

of the northern forest and of some natives to sleep in the open.

Winds are of course never strong in the woods, but there may be a breeze. You then make a windbreak against this out of logs and evergreen boughs. Even if there is no breeze you still put up the equivalent of a windbreak for it acts as a reflector against the fire that you are going to build. Between this windbreak and the fire you cover the snow with spruce boughs to keep your blankets away from the snow. In front you build a long and narrow fire, parallel to the windbreak and 6, 8, or 10 feet away from it, according to circumstances. This fire is best made by laying whole logs parallel to each other. To keep such a fire going there must be a minimum of three logs at a given time—two will not burn. You can, of course, use shorter pieces of wood if logs are not available; and you use short pieces as kindling or to revive the fire.

This type of fire can be built in a way to last 2 or 3 hours. If one or another of the campers will replenish it three or four times during the night, the party will sleep in fair comfort. At any rate, you escape the draft that is unavoidable in a tipi.

The marginal forest Indians, as, for instance, the Loucheux at the head of the Mackenzie delta and on the Peel River, had winter tents or winter camps that were a sort of incomplete adaptation of Eskimo shelters. They were not as simple or comfortable as those Eskimo tents and houses of which they were imitations and are, therefore, not worth discussion in a practical manual, although of considerable scientific interest for those who want a grasp of the cultural history of the two peoples. That the Indians borrowed, or tried to borrow, from the Eskimos, and that the Eskimos did not borrow from the Indians, seems logical to those who have lived among both peoples. For practically every forest Indian method or device was less well adapted to its purpose than the corresponding Eskimo feature.

SECTION III

ARCTIC FUEL AND HOW TO USE IT

STRIKING A LIGHT

Intimately connected with the problem of emergency fuels is the question of emergency ways of striking a light. The best is the use of iron pyrite. This is found on a good many of the Arctic islands and on many parts of the mainland coast. If you watch for it as you travel, you will likely find some in a day or two.

In summer you just carry along two chunks, each your idea of a right size to handle. The standard Eskimo size is about the shape and dimensions of a lemon. For cold weather use these should be about two-thirds covered (best with rawhide, for that shrinks into snug position after you have sewed it on).

When a fire is to be lighted you spread out any kind of tinder, preferably in a place where it can be reached by wind but not by rain or snow. Best is a large pad, say the size of an ordinary correspondence envelope. The tinder may be anything that catches fire easily, such as rotten dry wood or pussy willow fuzz. Strike the stones together and a shower of sparks falls on the pad, dozens of them probably catching. If the wind is right, it fans the sparks into a glow. If there is no wind, you or your helper must keep blowing. When sufficient of the tinder is lighted, you pick it out of the pad, transfer it to the vicinity of the dry kindling and let the wind blow on it some more or else blow on it yourself.

This method is so well adapted to stormy weather that Stefansson found on his second expedition when parties of civilized Eskimos, using matches, and uncivilized Eskimos, using pyrites, were traveling together, the uncivilized usually got their fire started with less trouble.

BOW-DRILL

With a bow-drill or something similar you can twirl the rounded end of a fairly hard stick in a socket in a piece of softer dry wood and get a fire if you work hard and are skillful. Many Eskimos know this method, but few use it—none when pyrites is available.

STOVES AND FIREPLACES

In such case as the wreck of a ship or the arrival of a sledge party at a coast, there is usually something available (perhaps gasoline tins) out of which a stove and stovepipe can be constructed. If wood is to be burned, a stove is much better than an open fireplace. (See description of fireplaces *ante*.) The difference is still greater if you are to burn coal, and that may well happen; for if a ship has been crushed between floes or against a beach you would normally have coal. Or a sledge party may discover a coal outcrop—as the Stefansson expeditions did at several places during various years.

COAL

Across the entire Arctic from Canada through Siberia, coal of satisfactory quality for use (though sometimes scarcely of commercial saleability) is found in almost every other river valley. In some creek mouths pieces of coal-float indicate that there are veins inland. This coal usually lends itself to surface mining and is commonly a fair quality lignite. You will occasionally find a sort of pitch which can be used for kindling. It burns with a flame like that of sealing wax, with a very black smoke and an odor resembling asphalt. Other coal has much the appearance of wood compressed into bricks and irregular fragments. On sea beaches in some places, as between Barrow and Icy Cape, you find coal sometimes in windrows. This has been scooped from the sea bottom and piled up there by ice that was pressed toward the coast by wind or current.

Coal was used extensively by a Stefansson wintering party at Cape Grassy, in northwestern Melville Island, near 76° N. Lat. They also found coal on Lougheed Island, considerably farther north.

If coal is to be burned, starting the fire is sometimes difficult. At Grassy, asphalt was found which served for kindling. You might happen to have a little wood to start coal fires or you might start them with animal fat burning on some kind of wick, such as broken-up dried bones or a piece of rag. It may be necessary, if kindling is scarce and coal abundant, to keep fires going day and night, perhaps standing watch-and-watch for that purpose.

You will occasionally come upon wood partly turned to coal, reddish in color. Sometimes this burns with such an agreeable smoke that you will stand in its way to sniff it—an incense effect, from tree gum that has been preserved.

Driftwood, which was once piled high on northern beaches, has grown scarcer every year since the custom of burning wood in stoves instead of animal fat in lamps spread far among the natives. In northern Alaska and northwestern Canada driftwood is usually found in great abundance, though sometimes exclusively on westward-facing beaches. This is because low waters occur with easterly winds and high with westerly; the westerly wind with its high water lodges the driftwood well above the reach of the most violent easterly gale, the while it carries away whatever the easterly wind may have brought.

There are similar regularities on other coasts, depending on the prevailing strong winds. This dependence of driftwood on certain winds in most of the Arctic is because of the insignificant tides there—see Chapter 2.

Willows (not only true willows but alders and other species) and small resinous plants are the most widely distributed fuel sources of the inland Arctic. Willows found on many of the Arctic islands are of considerable value for fuel if you take the roots along with the stems. Sandy ground where "heather" either does not grow or does not burn well seems specially adapted to a certain kind of willow, the dead and bleaching roots of which will there be found in sufficient quantity for cooking.

As an Arctic fuel, the resinous plant *Cassiope tetragona* (a sort of white heather) is far more valuable than willows. We repeat here what we said in Chapter 6 that an important element in what might be called polarcraft is to learn during summer to recognize locations where this heather will grow. Then during the winter you can go with some confidence to places covered with several feet of snow, dig down, and likely to find your fuel.

This heather is in winter always dry and in ideal condition for burning. In summer it is likely to be damp with a rain or a fog. Even if soaking wet, it burns if you once get a fire started with something else for kindling and with a breeze

blowing for a good draft. Therefore, you usually have to do your cooking in a particularly open spot, as on top of a hill. You can arrange for some increase of the draft by putting up flat stones or pieces of sod that will focus the wind.

KINDLING

Traveling in rainy weather across an Arctic prairie where you fuel is going to be *cassiope*, it is well to carry along kindling or to pick up some if you happen to find it on the march. For instance, a little heather may be discovered growing in such shelter that it is dry even on a rainy day. Pick it up and carry it underneath your coat, if there is no better place, and use it for kindling at camp time.

When you are crossing gravel bars and are in any way of the opinion that fuel will be insufficient for your camp, pick up as you go along any little sticks and thrust them under the rope lashings of your sledge.

WOOD AND FAT

In traveling on islands in spring you will occasionally find one where there are no resinous plants and no mosses dry enough for burning. In this case you may be able to spare for fuel some wood you have with you, using it together with animal fat. Stefansson found that a piece of half-inch board 3 inches wide and 18 inches long, whittled or split, and burned with one-quarter of a pound of caribou suet is sufficient to cook at one time meat to last three men all day. When meat is cut into pieces about the size of sugar cubes and put on in cold water, it is cooked even before the water boils.

You can also cook with the hair and wool of a musk ox or of a grizzly bear. One hide will probably cook two or three pots holding 8 quarts each.

WHEN NOT TO BURN FAT AND HIDES

Of course, you do not burn skins for warmth or cooking if you need or may need them for clothes or bedding; nor do you burn animal fat if there is a chance of running out of food. It is much better to eat your food raw and to get your warmth from food eaten and clothes worn than to burn them for heat. This may seem an unnecessary statement to

put into a book; but members of the Franklin expeditions did continue to burn some of their food to cook the rest of their food even after they were on small rations and getting weak from hunger. Some of them starved to death as a directly traceable result.

SEAL OIL

For parties living by hunting, traveling over the sea ice, the great fuel is seal oil or blubber.

Under such conditions the seal furnishes food, clothing, heat, and light. The blubber of the animal is, if anything, even more important than the meat, for it must furnish heat and light as well as food.

OUTDOOR COOKING

Stoves for cooking outdoors with seal oil or blubber have been rigged by using a cylindrical galvanized sheet-iron tank, the sides and bottom of which were clinched as well as soldered so that it could not come to pieces upon application of heat. On leaving the base the tank was filled with kerosene; when this had been used the top of the tank was removed and a draft hole cut near the bottom; then halfway up the stove two or three heavy wires were run across for the cooking pot to stand on. To be suitable for cooking purposes these cylindrical tanks should have a diameter a little larger than your largest cooking pots and a height of about 15 inches.

WICK

In burning seal oil or blubber, as in burning tallow, you must have a wick. It has been said that asbestos might serve, since it could be used over and over again; but probably this would not work permanently, for the fibers would become so clogged with the incombustible residue of oil that its usefulness as a wick would be destroyed. Besides, there is a simpler method.

After your meals, save the clean-picked bones. When next the fire is to be built use a little piece of rag for kindling, not necessarily more than an inch square, soaked in grease and put on the bottom of the stove. On top of it make a little heap of the bones and on top of the heap lay several

strips of blubber, resembling so many strips of fat bacon. A match is touched to the rag and it burns like the wick of a candle, with the flame playing up between the bones and striking the blubber, which begins to try out so that the oil trickles down on the bones, making a film on their outside. Upon sufficient heating this film blazes up, and thereafter your fire burns with a furious heat so long as strips of blubber continue to be placed upon it.

You now stand your cooking pot, filled with meat and water, upon the cross wires within the stove 6 or 8 inches above the bottom. The flame first strikes the bottom of the pot and then spreads and comes up all around it, since the diameter of the stove is an inch or two larger than that of the pot. This brings the pot to a boil as quickly as would the large wood fire.

The disadvantage of this method of cooking is that the smoke of seal oil burned in this manner is thick and black and exceedingly sticky. It is, in fact, the best quality of lampblack and clings to everything. The Stefansson parties were careful not to have the tent or the sledges in the path of the smoke, and the man who was doing the cooking used to stand asidle, once his fire was started, and keep out of the smoke. White dogs that lay in the path of the smoke were nearly black after the cooking of one meal.

Eskimo stone lamps, which are used both for cooking and for heating, are large half-moon-shaped bowls that have been dazed or scraped out of blocks of native soapstone. The wick is a ridge of powder, of one of the materials described below, lying along the straight edge of the lamp.

Members of traveling parties should know what makes a good wick for an Eskimo-type oil lamp. The best answer is that almost anything serves if it is dry and you know how to handle it, which comes from practice. Thoroughly decayed soft wood is fair, hardwood sawdust is excellent, soft wood sawdust is medium. The Eskimos sometimes use scraped walrus ivory, dried moss that has been rubbed into powder between the hands, or the fuzz of pussy willow. Occasionally, if other materials give out, "civilized" Eskimos will take small pieces of manila rope and hack the fibers into lengths of one-twentieth of an inch or less, thus practically

converting the fibers into powder. Stefansson reports seeing commercial smoking tobacco used with good results and without causing an appreciable tobacco smell in the house. He once tried using ordinary commercial lamp wicks but they were difficult to keep burning so they did not smoke.

For ideal burning, the bowl of the lamp must always be almost full of oil but never quite full. This may be regulated automatically. A slab of polar bear or seal fat is hung almost over the flame. If the oil in the lamp gets a little too low, there is more of the lamp wick exposed and the flame becomes larger; the increased heat of the flame tries out the fat hanging over it and makes the oil trickle down more rapidly. This gradually raises the level of the oil in the bowl until it floods part of the wick and decreases in that way the size of the flame, which in turn cools off the vicinity of the lamp enough so that the slab of blubber stops dripping. Then the flame gradually increases in size as the oil lowers in the lamp until a second flaring-up again brings streams of oil down from the slab of fat.

An Eskimo oil lamp that is kept properly trimmed produces no smoke and will burn with regular fluctuations 6 or 8 hours at a time. Ordinarily lamps that are trimmed when you go to bed in the evening are still burning brightly the next morning, unless you have forgotten to put a large enough piece of blubber on the hook above the lamp.

All Eskimos, but particularly those who live in snow houses, are meticulous that a lamp shall not smoke. Their sense of smell (though perhaps not their other senses) seems keener than ours and there is nothing disturbs them so quickly as the least bit of that odor which goes with the formation of lampblack. Accordingly, there is instant attention from the first person who smells a lamp smoking—he fixes it himself or warns someone who is nearer. Stefansson reports that, as a result, he has seen snow houses of Eskimos (who did not use tobacco) where, after 2 or 3 weeks of lamps burning day and night, there was less stain on the ceiling than would have been produced by one evening of moderate cigarette or pipe smoking. The likeliest time for a lamp to smoke is at night when people are sleeping. Lamps will, as said, burn without smoke unattended for

long periods; even the least smoke will awaken somebody who promptly attends to the lamp.

LIGHT

In houses of earth-and-wood, or in lined snow houses, the pot swung over the lamp so obscures the light during cooking periods that other lamps are burned exclusively for lighting. In snow houses, however, the back and forth reflection of light from the spotless snow walls sees to it that the same lamp which does the cooking also furnishes enough light.

SUPERIORITY OF IMPORTED FUELS

The foregoing are fuels indigenous to the Arctic and, as indicated, are satisfactory when commercial fuels are not available. When circumstances permit, however, kerosene should be carried. We repeat here what we point out in Chapter 11, that hauling fuel along with you is more important than hauling food and that the kind of fuel is more important than the kind of food. Better light and more convenient heat are derived from kerosene burned in lamps and in blue-flame stoves than are to be had from seal blubber burned by any method so far devised.

We do not describe kerosene lamps and stoves; for better ones designed for travel use are constantly being developed and invented.

CHAPTER 8

FOOD AND DRINK

Whatever rations a party starts with are fairly sure to be all right, particularly if they are from Army stores. We devote ourselves chiefly, then, to discussing foods which may be picked up along the way, prefacing, however, with a brief discussion of special methods and special foods for cold weather travelers.

SECTION I

SPECIAL METHODS

If weight is of no consequence because the journey is short, or because the transportation facilities are unlimited, you take with you whatever food you like, except, of course, nothing that is going to spoil. What foods will spoil in hot weather, and how this can be avoided, is so well known that it needs no discussion. There are not many foods spoilt by cold, or at least not materially. Potatoes, if frozen once for all (if not intermittently frozen and thawed) are almost as good as if they had not frozen. The same is true with eggs, apples, and the like. Meats are so little affected that it takes discriminating if not expert judgment to tell the difference between those that have been frozen and those that have not.

There is, of course, a great deal of prejudice against frozen foods. But this is probably in the main just a lot of folk beliefs. Certainly it is on the whole more advantageous for

a traveling party that everything should remain frozen than that everything should remain unfrozen; for when things are unfrozen it is frequently difficult to keep them from souring, decaying, or being otherwise spoiled—it is almost impossible to spoil a food while it is frozen.

Under permanent conditions of thaw, or conditions of intermittent thawing and freezing, you have to be very careful about how things are packed; under permanent frost practically no care is required. Milk can be frozen into bricks and handled like bricks. Meat can be cut into separate steaks or roasts before freezing and then handled like chunks of wood. You can carry your meat in large pieces if you like, as an entire ham or even a carcass. Then, when meals are to be cooked, you cut up the piece with saws or axes. Saws are generally better, for with intense cold an axe will splinter meat and some of the splinters may be lost. Sawing does, of course, waste a bit of the meat if you are not careful; but you can always gather the sawdust together and save it.

All foods can be carried frozen and handled with freedom except those that are greasy. Even greases freeze "clean" when it is cold enough. Some of them like tallow, may be freely handled, without much staining of mittens, at temperatures only a little below freezing. Butter is clean to handle at zero. Lard will not grease you up much at temperatures of 20° or 30° below. At 50° below zero any fat can be handled in chunks except a few of the oils, such as whale and seal. These are in a semiliquid state, and behave as we are used to think of grease as behaving.

A food much carried in the North, if weight does not count, is baked beans. Most people have them frozen into bricks. However, they are more convenient if you bake them dry and let them freeze in separate kernels so you can handle them like a bag of peanuts. For warming up, whether the beans are in bricks or separate, you have a little water in the pot or a little grease in the pan when you start the cooking.

If fuel is likely to be scarce, certain foods are to be avoided. If you have plenty of fuel and plenty of time you would naturally carry uncooked things, like beans and rice. Beans are among the slowest things to cook, requiring leisure

and much fuel. Rice and oatmeal, although usually avoided because said to require a lot of fuel, can be cooked with a minimum. What you do is to put them into the cooking pot on top of the snow, if you are going to cook with snow water, or on top of cracked ice if that is going to be your source of liquid. You must be careful, of course, that cereals and things of that sort are not right on the bottom of your pot before the snow or ice begins to melt, for then they will burn.

If cereals are in the pot when the snow is being melted or are put in with the cold water, and if the fire is slow as a seal oil lamp will be, then they are nearly cooked when the water comes to a boil. It was standard practice on the Stefansson expeditions when rice had to be used to take the pot off the fire 1 or 2 minutes after it came to a boil and to stand it on a piece of wood or other nonconductor, the pot being also wrapped up in a blanket or placed under a skin—a fireless cooker effect. Twenty or thirty minutes after being taken from the fire the rice would be adequately cooked. Oatmeal cooks still more easily.

A good way to use beans, peas, or lentils is to have them ground up into coarse flour. They cook, then, with hardly more difficulty or time than oatmeal.

Traveling parties that are self-supporting, of course, live on whatever game there is in their district. We discuss elsewhere cooking and housekeeping under those conditions.

SECTION II

SPECIAL FOODS

FAT IN THE DIET

We shall see as we go along why fat is the most important ingredient of an Arctic ration. We begin with considering some beliefs in regard to this food which do not appear to be well founded.

It is a common view that people like fat in cold weather, dislike it in hot. A variant is to say that fat is good for you in winter and bad for you in summer. It is difficult to guess what may have been the origin of this belief for, although widely held, it is contradicted by universal experience. For

instance, it is a common objection of North Americans to Latin American food that it is greasy. Northerners within the United States who go to the southern states find that a lot of fat is eaten—fat pork and corn bread is a standard diet at least among certain classes. Few animals are greasier than the opossum; yet this is a delicacy in our South with negroes and apparently with many of those whites who have tried it. Carl Akeley reported from Africa and Carl Lumholtz from Australia that natives there would gorge with fat. The early Australian sheep men (English), according to Sir Hubert Wilkins, roasted the fattest mutton and dipped it in drippings—which was, of course, in the early days before sugar was abundant. When Homer is trying to bring out that the gods had more delicious food and lived more sumptuously than mortals he did it in part by saying that they were able to command meats that had more fat on them than available to mortals. Dr. Edgar Johnson Goodspeed, one of the foremost of our biblical scholars, has given it as both his view and that of several colleagues whom he consulted that the Jews in "Biblical times" were extremely fond of fat mutton.

However, this must not be taken to overstate the case to the effect that people in hot countries are more fond of fat than in cold. They do *seem* to be more fond; but this is no doubt because, on the average, fats are harder to secure the warmer the country. This is for complex reasons which we have not space to discuss. We just state the fact, which anyone can prove to himself if he stops to think, that on the average the animals of the coldest countries are the fattest. Insofar as man is a hunter he lives on fat animals in cold countries and animals comparatively deficient in fat in hot countries. Thus it is in hot countries we are likeliest to find people who are fat hungry. This is why fat animals, like the opossum and pig, are delicacies in tropical and sub-tropical lands.

The fact is, apparently, that the normal human craving for fat is, in ratio to other foods eaten, just about the same in all climates. You eat more in winter than you do in summer; to that extent only do you eat more fat in winter than in summer. One of the many cases where this has been proved is that of Stefansson and Anderson when in 1928–29 they lived, under

the supervision of the Russell Sage Institute of Pathology for 12 months and some weeks on an exclusive meat (lean and fat) diet in New York City. They ate more in winter than in summer, but the proportion of fat to lean remained about the same.

Another seemingly unwarranted belief concerning fat is that it is a better heating food, produces more heat in the human body, than any other. This is probably not true in any sense except that of containing more calories per ounce. You probably get just as much heat, and get it quite as easily, out of 9 ounces of sugar as out of 4 ounces of fat. Fat then, is the best of heat producers only in the sense that it is the most condensed of known foods—has the most calories per unit of weight.

There are a great many people who tell you that they "cannot eat fat." Among a hundred of these there may be one or two that really cannot—these may be "sensitive" too fat, allergic. The other 98 or 99 are merely describing to you a state of mind. If they happen to be for a number of days where the fat equivalents, sugar and starch, are lacking they will develop a taste for fat. There are cases on record where a man "never ate fat in his life" and acquired a preference for fat over sugar in half a year on an exclusive lean and fat diet.

It must be remembered, too, that a man's declaring he eats no fat may have a linguistic explanation—he may not speak of as fat what the rest of us call fat. Perhaps he will be found eating things like butter, gravy, hard sauce, and cream.

It is claimed on behalf of fat, and perhaps rightly, that it is the only food in which lies no danger of overeating, or at least no danger if you eat slowly. The contention is that with sugar at your elbow, or any food of which you are fond other than fat, you may eat a good deal more than you need and even possibly enough to hurt you. For an illustration of how this would not be so with fat, take cream, for this is to many a palatable form.

Get somebody who is extremely fond of cream, place before him a dish of it with a teaspoon and see that he does

not eat faster than 2 teaspoonfuls per minute. After the first 10 or 15 spoons he will begin to notice that each tastes a little less well than the one before. Presently, he will have no desire to eat. If he continues he will finally gag—either his will power will not enable him to swallow more or if he does swallow he will throw it up.

It is, of course, true that in eating any sort of food you do eventually get enough; however, the reaction against too much of other foods which are palatable is not so reliable or strong as in the case of fat.

Fat is, in calories, the most condensed of foods. An ounce of fat (butter, bacon fat, tallow) is more than twice as nourishing in the caloric sense as an ounce of sugar or an ounce of dried lean. If portability of a ration is being considered, it is then essential that it shall contain as much fat as the consumer can take without beginning to turn against it; the rest of his requirements will be supplied from other sources.

It is considered that the human body cannot repair itself without protein. Theoretically, then, the ideal condensed or portable ratio is as much fat as you need for calories and as much protein as you need for body repair.

The question of vitamins is discussed hereafter. We mention, however, that pemmican, the food towards a discussion of which we are working, contains an adequate amount of all the currently known vitamins, except Vitamin C. If your body is thoroughly stocked with C by a good diet previous to a journey, you will probably stay at optimum health on the journey, so far as you or anyone else can notice, for several weeks eating just pemmican and water. Thereafter will begin to develop slowly symptoms we shall discuss later in connection with scurvy, but likely you will still be able to report yourself in pretty good health after 2 months. It is somewhere between 6 weeks and 12 that you will develop pronounced Vitamin C deficiency symptoms—recognizable scurvy. (See Section IV, Chapter 10.)

Pemmican is, then, an ideal emergency food for a journey up to 6 weeks, after which it will have to be supplemented by other foods, or else the Vitamin C will have to be supplied as a drug, probably in capsule form.

Both the word and the idea, "pemmican," are from Indian sources. The essential ingredients are the two chief components of meat, lean and fat.

Many Indians who do not make pemmican carry with them on journeys whatever dried lean meat they have and carry fat separately. This may be, on the whole, better than using pemmican. The human digestive apparatus, and the associated feelings and "instincts," do not automatically prevent overeating of lean; they do prevent overeating of fat. For, as said, when you eat slowly something fat, the goodness of the taste decreases so that it is almost if not quite possible to notice decreased palatability with successive mouthfuls. If fat and other food elements are mixed, as fat and lean are in pemmican, you are either tempted to overeat of fat in order to get enough lean or else you may become improperly nourished in that the excessive fat begins to nauseate you before you have had quite enough of the lean.

The theoretically ideal ration, then, from the caloric angle, is a predetermined adequate weight of lean, supplemented each day by all the fat you want. The addition of other ingredients, such as sugar, raisins, meal, though some of them are possibly useful in themselves, go against what is the main idea with pemmican—to secure a maximum of nourishment with minimum of both weight and bulk.

The danger of too much lean against fat in pemmican is not solely one of faulty economy. If the excess of lean over fat is sufficiently marked, the men eating it may develop protein poisoning—nephritis. This was undoubtedly the cause of at least one death in the Bartlett party of the third Stefansson expedition.

What is probably a good standard for pemmican was determined at the Russell Sage Institute of Pathology of New York when Stefansson and Andersen lived a year exclusively on meat and water. It proved that on the average their requirements were supplied by about 1⅓ lb. of lean and ½ lb. of fat. No salt is necessary. Should the Army decide to make pemmican, or have it made from specifications, this would be a reliable guide—probably better than anything else now available. (The weights given are for steak and suet before either was cooked.)

DANISH PEMMICAN SATISFACTORY

Pemmican has in the past been made by guess and rule of thumb. What seemed to be the best ever tried by the author was made by the Beauvais firm of Copenhagen, and was approximately half powdered lean meat and half tallow. This pemmican was made in blocks somewhat the shape and size of house-building bricks. The bricks were wrapped in tinfoil, which may have been of some help for keeping the food in good condition but was a nuisance to the users, for the foil stuck. Perhaps the blocks of pemmican might be wrapped in some form of oiled paper. The wrapped Beauvais bricks were packed in a 10- to 14-inch cubical tin. Such pemmican has been found in good condition after half a dozen years, at least one summer of which had been under temperate zone conditions.

AMERICAN PEMMICAN NOT SATISFACTORY

Pemmican thus far commercially made in the United States has been of only partly dry meat. In the pemmican of the third Stefansson expedition, excessive salting was used by Underwood for extra safety along with the canning; Armour seemed to depend mainly on the cans and the canning process for preservation. The Underwood pemmican contained far too high a percentage of lean, and the Armour product contained an unnecessary and uneconomical admixture of vegetable matter.

If the meat is thoroughly dry when ground, and if the only other ingredient is beef or mutton tallow, no canning of the individual pieces is necessary in the Arctic and the above-described Danish method of packing is advisable.

If pemmican is bought canned, the tins can be removed just before a winter journey starts—they always should be, for they are extra weight and in winter have no value for anything, unless it be as protection from dogs.

The first reason why pemmican should not be salted is that whoever wants salt ought to be allowed to use it to his taste. A further reason is that salt increases thirst; and, although it is safe enough to quench this by eating snow as you walk along, it is a nuisance to have to be reaching for snow all the

time. Besides, salt appears to have a particularly bad effect on dogs—the above-mentioned Underwood pemmican made dogs sick.

Additions to pemmican have included fish meal among Scandinavians, and chocolate among various nationalities. These have been put in either according to some theory or to "improve the taste."

There is no need to improve the taste of pemmican. All who have used it in its fundamental or nearly fundamental forms have liked it. (True enough, many also have liked the variants.) Peary says, for instance, that his standard daily ration of 1 pound pemmican, 1 pound biscuit, and tea with a very little sugar for sweetening, was satisfactory both in keeping up the strength of the party and in that nobody got tired of it. (This ration, however, would not do for more than, say, three months, as appears in what we say about scurvy in Chapter 10.)

Peary used hard bread (pilot bread) with pemmican because he thought it was needed to supply bulk, and possibly for other reasons. Members of various Stefansson parties lived for as long periods on dried lean and dried fat, the ingredients of pemmican, eaten separately, as any of the Peary detachments ever lived on the pemmican and biscuit. The results were equally good in both cases—the biscuits did not prove disadvantageous, except perhaps in being bulkier on the sledges and then in supplying less nourishment per pound; neither did they prove themselves advantageous, since the results were also perfect without them.

The fundamental reason why there is no cause to flavor, disguise, or in any way "improve" the taste of pemmican is that men who work hard have such good appetites anyway that it is enough of a strain on their will power to keep to a ration even when it is not particularly appetizing. Besides, it is true with pemmican, as probably with most or all foods that are complete in all the dietal requirements, that the longer you eat them the better you like them.

Pemmican can be eaten as if it were chocolate. That is how Peary used it. Tea was the liquid they had with their biscuits and pemmican. Some expeditions have preferred

to do without the tea and to get their liquid by making a thin soup of the pemmican. In that case, usually each man would break his individual ration of biscuit into his ration of pemmican soup; or some of the biscuits might be pooled and put into the pemmican stew just before it was ready to serve.

CHOCOLATE AND RICE GOOD CONDENSED RATIONS

Although not nearly as rich in calories, pound for pound, chocolate is usually looked upon as good condensed rations. Rice is another. On the third Stefansson expedition, where fuel did not have to be economized because it was secured along the way through killing seals, one of the favorite rations was a stew made by boiling rice in a lot of water to which were added chocolate and lumps of chopped-up suet—in that instance caribou fat.

Peary never got full satisfaction for men working hard under much less than 2 pounds per day of his pemmican-biscuit-tea-sugar ration; the Stefansson party got results which appeared satisfactory, at least for a week or two at a time, from something like half a pound of rice, half a pound of suet and a quarter pound of chocolate. However, the Stefansson parties depended so largely on hunting that they seldom had occasion to use substitutes for very long—chiefly in the midwinter period of inadequate hunting light; and even then they used to secure game occasionally.

DRIED FISH

For men and dogs dried fish is a good as well as a cheap ration. Along the Yukon River, and elsewhere in Alaska, dried salmon are put up by the ton, and an expedition planning to go into the sea north of Alaska could, especially by a year's advance arrangement, secure great quantities of this excellent food to take along. It needs no preservative even on a ship's deck, except against the sea washing over it or against rain. The Stefansson experience was that the men became very fond of these dried salmon, in some cases retaining the fondness after they had returned to civilization, but at any rate greedily eating quantities when in the field, winter or summer. The salmon, dried native style, are not salted.

SECTION III

LIVING OFF THE COUNTRY

a. Food Sources

In much of the Arctic, about the only food you can pick up along the way is derived from animals you secure. (See Chapter 6 for Arctic vegetable sources.) Our main discussion, therefore, relates to a meat diet, which we define as one from which all matter directly from the vegetable kingdom is absent. Here we deal only with the types of meat that are likely to be secured in the North, with the preferences as to parts of the animal, and with cooking methods. In chapter 10 we discuss at length the relation of a meat diet to health, both physical and psychological.

b. Palatability

FAVORITE NORTHERN MEATS

The usual view of northern meat eaters is that caribou is the best land animal and seal best at sea. White newcomers are likely to prefer the musk ox. This is because it is practically identical with beef, while caribou has individuality.

MUSK OXEN

Some travelers have stated that the flesh of musk oxen is strong—that it tastes of musk, from which the animal is supposed to have received its name. Observers who have lived on these animals for long periods say, however, that the strong taste is found chiefly in old males and that it is no stronger than the corresponding taste with old seals, old caribou, or with old domestic sheep.

A strong taste in old caribou is seldom reported because animals are killed by wolves before they get old—few people, Eskimo or white, have ever had an opportunity to taste an old bull caribou. Seals, musk oxen, and mountain sheep live much longer, especially musk oxen, which apparently either die of old age or are killed by wolves only when they have become decrepit.

Peary said that musk ox was better than domestic beef, but he probably meant only that his appetite was better when he

was eating it, since the two seem almost indistinguishable. In color and flavor the fat of the musk ox is similar to that of beef, though not practically identical as is the case with the lean. Stefansson's companions agreed they preferred musk ox fat to beef fat; and further agreed that there is more range of flavors as between fats from different parts of the body. The largest accumulation is on the neck, and this is especially delicious.

MILK

No northern wild animal gives a large amount of milk, not even the huge moose. Domestic cattle, when allowed to run wild on the range, give only from 3 to 5 pints of milk where the same cow would give four times that much under dairying conditions. Under the circumstances musk oxen give surprisingly much. In flavor the milk is about like that of the Jersey cow, though somewhat richer, for the "whole milk" is about the consistency of commercial light cream. Probably the percentage of fat in the undiluted milk is not as high as in city cream, but the consistency does give a creamlike impression.

POLAR BEAR

Europeans commonly like the taste of bear meat, saying it is like pork. But it is stringy, gets between the teeth, and makes the gums sore. After you have been on bear for a week or two you are likely to begin cutting it in small pieces and swallowing them before you are through chewing. This applies to cooked meat, not to raw. Cooking increases toughness and brings out the stringiness. Chewing frozen raw bear meat is like eating raw oysters; half-frozen it has, like other raw meats, the consistency of hard ice cream.

It is commonly said by whalers that Eskimos have told them polar bear liver is poisonous. What the Eskimos have said is that if you eat bear liver you will get sick. When Stefansson became familiar with their language and their manner of thinking, he learned that what they meant was that bear liver is taboo and if you eat it punishment in the form of sickness or death will follow. But this did not seem like a rational belief, for the illness or death were supposed to

afflict members of a family irrespective of which had eaten the liver. On his third expedition he therefore conducted a series of liver-eating experiments. They found the taste pleasant, about like that of calf liver. On about 90 percent of the tests there were no ill effects; on the remaining 10 percent the experimenters became temporarily ill, recovering in a day or so. The only conclusion they could draw was that certain livers of bears may be slightly poisonous while others are not.

SEALS

With seals there is little preference between parts. Most people like the liver boiled, or frozen and raw. The heart is liked and the kidneys. Practically all parts of the body, except the entrails, are much on a level.

CARIBOU

With caribou, the other great food animal of the North, there is a scale of choices and there are marked preferences. The best is the head. Next come brisket, ribs, backbone, and pelvis. The brisket is too fat at certain times of year and in that case you peel much of the fat and nearly all the lean away before boiling the bones. Ribs are seldom considered too fat, but some of the ribs have too much meat on them, which is removed before cooking. Similarly a considerable part of the meat is cut from the backbone before cooking. For Eskimos and all other meat eaters agree with the Elizabethans that the sweetest meat is nearest the bone.

The halfway parts of a caribou in dividing the food between men and dogs are the neck and shoulders. The men usually get them while the dogs get the hind quarters.

Most Eskimos are very fond of their dogs and so are many whites, but they agree on keeping the best parts of animals for human use. Accordingly, you begin the dog-meat classification from the opposite end of the scale. They get first what we think worst—the entrails and lungs. Usually the humans get the heart and kidneys but the dogs get the liver, sweetbreads, and all other internal organs and glands. As said, the dogs get the hams, unless the men are so much more numerous that they need them.

The great particular delicacies of the caribou eater are the various fats. Except perhaps some of the marrows, the best is that behind the eyes. There is also some very good fat under the lower jaw. When caribou are skinny the tongue is much fancied, for it usually contains some agreeable fat. Another good fat is around the kidneys.

The least favored is the slab of fat which lies along the back. In the case of a very fat full-grown bull the layer may be half an inch thick at the front of the shoulders, just where it goes over on the neck, and at which point it is usually severed from the neck fat. Back on the shoulders it thickens, particularly in two ovals, one each side of the ridge of the back, just behind the shoulder blades. Then it gets perhaps a litle thinner but rapidly thickens again until just in front of the tail it may be (some say) 3 inches thick. A slab of this fat peeled from a bull of 300 pounds live-weight may weigh 30 or 40 pounds.

In the economy of both caribou Eskimos and northern Indians the back fat is important. It is always separated from the body.

Among the Indians it may be smoke-dried, while the Eskimos usually dry it by just hanging it up, though a few also smoke it. As said, it is valued because of its massiveness, not for its quality. Most people prefer many of the other fats.

One thing dogs never get is the marrow bones. The meat is peeled from them, sometimes to be cooked, sometimes to be given to the dogs. The bones are then broken for marrow in the fashion of Stone Age man. The only marrow bones that are customarily boiled or roasted by Eskimos are the humerus and femur, which are cooked with a certain amount of meat still adhering. The rest of the marrow is eaten raw.

When you take them at "room temperatures," the marrows farthest from the hoofs are hardest. At the head of the femur and humerus it is approximately as hard as reindeer or beef tallow; at the lower end of the same bones it is softer and the top of the next bone is softer still; it continues in that way until finally toward the toes the marrow is liquid and almost the color of water.

Meat is a complete diet only when the animal you eat is fat. It is therefore easiest for the most northerly men of the northern hemisphere to secure an adequate diet by hunting, for it is there that the animals are fattest. The whales, the walrus, and the seals are so fat that if you secure enough of them to furnish the protein necessary for the health of men and dogs you at the same time secure so much fat that even when all cooking, househeating, and lighting are done with oil, there is still a surplus. Stefansson found when traveling over the sea ice and living exclusively on seals that when the fat of animals secured had been put to all its uses he still had to throw away about a third.

But these are the only northern animals that have an excess of fat.

A polar bear may be either skinny or rolling at any time of year, according to his individual luck in hunting. If you were to live exclusively on polar bears you would be hard put to it—you would have to eat as much lean as your health permitted, always being careful of the fat.

Grizzly bears are fattest in the autumn just before hibernation. There may be nearly a hundred pounds of fat on a 500-pound bear. They awake from the hibernation in the spring practically as fat as when they retired in the autumn; but these vegetarians awake in April and are not able to dig roots until the ground thaws, which may be 6 weeks later. During this fast they lose fat rapidly and are fatless when the thaws begin. Hunting man would find it difficult to manage a normal diet on that kind of animal.

We have already dealt with the fat cycles of the musk oxen and caribou. The moose has a like cycle. You cannot therefore have a balanced diet on these animals any more than you can on the grizzly bear, if you kill each month those that you eat that month. The only way to manage with beasts of seasonal fatness is to kill a large number at the top of the fat cycle and to preserve the fat.

Some animals are never fat. The only one of these important in northern economy is the rabbit. It is recognized that you cannot live on them exclusively. The expression "rabbit starvation," common in the North, sounds as if you were talking about there being no rabbits. What the phrase

means is that the people have been reduced to living on nothing but rabbit.

RABBIT STARVATION

If you are transferred suddenly from a diet normal in fat to one consisting wholly of rabbit you eat bigger and bigger meals for the first few days until at the end of about a week you are eating in pounds three or four times as much as you were at the beginning of the week. By that time you are showing both signs of starvation and of protein poisoning. You eat numerous meals; you feel hungry at the end of each; you are in discomfort through distention of the stomach with much food and you begin to feel a vague restlessness. Diarrhoea will start in from a week to 10 days and will not be relieved unless you secure fat. Death will result after several weeks.

Some Arctic birds are well supplied with fat, but only those that migrate. Geese and ducks are fat in the spring and never quite without fat during the summer, fattening again somewhat in the autumn. Swans have a good deal of fat but cranes do not. By common northern opinion, Eskimo and white, the owl is one of the best of the food birds, but it has inadequate fat. Ravens are not considered good, because they are skinny. The ptarmigan has little fat. These three are the chief birds that spend the whole year in the farthest north, the owl, the raven, and the ptarmigan—some of them go south but some stay.

On the average, fish have enough fat in them for food but little or nothing over for lighting, cooking, and heating purposes.

There are only two things out of the ordinary to be said about the palatability of fish.

All Eskimos and northern Indians seem to agree that in the case of most fishes, as with caribou, the head is the best part of the animal. The Eskimos, who are extremely fond of their children, usually reserve fish heads for them, and thereafter for visitors. Unlike the caribou head, which may be either boiled or roasted, fish heads should always be boiled. The northern general attitude towards fish heads is, then, what the New England attitude is towards them

for chowder. Nor is it unknown in Europe that fish heads are a delicacy—people are very fond of them in certain parts of Norway and in other countries.

COD LIVERS A DELICACY

A thing known to some Europeans is a commonplace in the North, that cod liver is the most delicious form of fat. The greatest of all delicacies is the liver of the fresh-water cod, the ling. These are eaten boiled.

SKIN CLOTHING AND BOATS IN CASE OF STARVATION

In discussions of skin boats and skin clothing, we have pointed out that, before the extremity of cannibalism is reached, all articles made out of rawhide or hide not commercially tanned can be used as food. They have considerable food value and there is no substance in them that tends to make you ill.

c. *Cooking Methods*

BOILING BEST METHOD OF COOKING

The easiest method of cooking, and the one best liked in the long run, is boiling.

On shore or at sea you will have fresh water for cooking in summer and autumn—on shore this is from lakes and rivers, at sea it is from rain or thaw water on top of the ice. But, in winter, sometimes on land and always at sea, you are dependent on snow or ice. Typically you begin cooking with your pot three-quarters filled with cracked ice; on top of that you pile chunks of meat, a few of them as small as your closed fist but the average size perhaps that of both fists held together—except, of course, the parts which are thin, like ribs. As the ice melts the meat sinks down. While the water is gradually warming up the meat thaws. When the pot comes to a boil, or perhaps 2 to 5 minutes later, you take it off the fire and set it on some nonconductor such as a piece of wood, for the cooking to proceed fireless-cooker style. It is a good thing to have something special along for this purpose. You may have with you a wooden box which contains pots and other things when you are traveling; this box can be used as a fireless cooker at mealtimes.

The reason for taking the meat off as soon as it comes to a boil may be any one of several, or a combination of them. You may be saving fuel; you may need heat for the warmth of the room, in which case you want it direct and dry rather than indirect by way of the steam from the boiling pot. It may be the nuisance of the steam itself is your chief reason, for perhaps it is condensing on the roof of a tent, thence to drop later in snow form on your bedding to make it wet.

In any case, the meal is sufficiently cooked, for in the long run you find it best to boil meat about as rare as we roast beef. Our typical roast is well done only for a small fraction on the outside; inside there is a layer that is medium done, and innermost what we call rare, which is really raw. The eaters of boiled meat like the same to be the case, having the inside of each piece rare or medium. This practice has developed, no doubt, in response to taste or, shall we say, instinct. Scientifically speaking, oxidation destroys or weakens vitamin C in those outer layers of the meat which are well- or over-cooked. There is little oxidation on the middle layers and practically none on the raw (rare) central portion. Therefore, you are always protected from scurvy so long as your meat is cooked in approved Eskimo fashion. (See also Chapter 10.)

Meat eaters do not, properly speaking, have soups, but it is customary with some of them that when meat has been boiled it is removed from the broth and then a little blood poured in, the whole stirred meantime. This produces, with the right proportions, a broth of the consistency of pea soup.

Frying, besides being a method of cooking unknown to most if not all of the "native" races, is least likely to be convenient. If it is convenient, and if you like fried things, there is no argument against it. Whites, no matter how long they have been on meat, are likely to get the notion occasionally that they might like fried liver. Even in this case, however, the general preference, growing stronger with the years, is for the liver either boiled or, if raw, frozen. Generally, as explained elsewhere, it is only seal livers that are used as human food—caribou liver is usually dog feed and bear liver is thrown away.

It happens frequently on land, though seldom if ever at sea, that roasting is more convenient than boiling. Perhaps you have killed a caribou and have no cooking gear. Then you make a fire and hang the meat at the right distance from it; or else you hold it toward the fire on a stick. There are various methods, and all of them are so familiar to whites who have done any camping that they are not worth describing in detail—except for one part, the head of caribou or moose.

METHOD FOR CARIBOU OR MOOSE HEAD

As said, most or all meat eaters believe that with caribou, moose, and with most of those fish which have large heads, the head is the best part of the animal. Usually these are eaten boiled; but many, and particularly the Indians of the northern woods, consider that either caribou or moose head should be roasted.

You do nothing to the head except skin it and remove the tongue—in some cases the brain may be removed, but not ordinarily. A head is so big that about the only suitable way of roasting it is to suspend it by the nostrils with a fairly long string, one that allows a good deal of spinning. You start the head spinning in one direction and keep it going for some time, then you stop it and it spins back again, and then back and forth for several minutes. When it is about to stop you are there to get it well started on the second cycle.

It takes between 1 and 2 hours to roast a head. In any case, there are few experts who can tell offhand when a head is done. So if you think that it may be nearly done, you just pull it away from the fire occasionally long enough to examine it.

FISH USUALLY BOILED

Even more decidedly than with meat, boiling is the preferred cooking method with fish. We have mentioned that heads are always boiled; the same is usually true of the rest of the fish, if it is fresh. The chief exceptions are with fish that is high or that has been dried.

Even high meat is usually eaten boiled. When fish are high they are seldom or never boiled. Eskimos are not fond of

gamey fish if they are unfrozen, and they are usually kept for dog feed unless there is an emergency. But after the freeze-up in autumn, fish that were caught at various times of summer, and which therefore are now in various stages of decay, are looked upon as a delicacy, somewhat in the manner of our cheeses.

If not intended for drying, fish caught in midsummer are piled in windrows and covered with logs to protect them from dogs, ravens, foxes, and other thieving animals. On the north coast of Alaska, where the freeze-up is typically in September, July fish is pretty well decayed by then, August fish is moderately high, while a late August or early September fish is practically or wholly fresh.

High fish are eaten for a snack, corresponding to a tea, a forenoon lunch, or a supper; but they may be eaten sort of as a desert in one of the regular meals. Eskimos and northern Indians do not generally have the desert eating habit; the Eskimo use of high fish comes nearest to it. Otherwise the northerly peoples eat more small boy style—they eat first what they like best and make a whole meal of it if there is enough. If there is not enough, they finish up on the next best.

DRIED FISH

The other exception to fish being boiled, is as said, that they may be dried. Whether for decaying or for drying, fish are cleaned (all entrails removed) immediately after being caught. For the decaying nothing else is done to them. For the drying, they are split and the backbone removed. Usually the backbone and head are dried together, the rest of the fish being split in halves and hanging together at the tail. Dried backbones and heads are intended for dog feed—this is almost the only case where dogs get a chance to eat heads.

d. Preservation of Food

The use of cold, both intense and moderate, for preserving food and the like is discussed elsewhere, but we here mention some points.

If animals are properly butchered, the meat without cover is perfect after 6 or 8 months of winter, except that, for instance, a ham may develop a sort of skin by drying on the

outside—this if it is exposed to the air but not if it is buried. Beans baked with pork will similarly be perfect for several months, although there may develop eventually a slight rancid taste in the pork. If you bake beans with fresh seal or whale fat, as whites in the North sometimes do, they will go rancid in a few days or weeks. The sea mammal fats become rancid even at the lowest temperatures if air gets at them.

If you are going to spend several years in a given place, you can store meat in underground chambers for years with only the precaution of avoiding certain molds that flourish at ground temperatures at least down to 20° below freezing. If these molds get into your storehouse you have to empty it of meat and destroy the mold either chemically or by peeling an inch or two of earth from floor, walls, and ceiling.

If an animal is buried so that the body is protected from air at average Arctic ground temperatures (from 0° to 10° F.), the flesh remains apparently practically unspoiled for thousands and perhaps tens of thousands of years, as shown by the remains of the now extinct mammoth which have been uncovered in the Arctic.

It has been reported by the Lomen Commercial Company and others that both reindeer meat and domestic beef have been preserved in perfect condition 4 years in galleries utilizing the natural underground temperatures of Alaska, as said, about 10° above.

Directly the best food preservative known, frost is indirectly valuable, too. For instance, if you want to dry fish or meat in summer you have to take some pains about keeping maggots out of them. If the season is rainy it may be difficult or impossible to produce good dried meat or dried fish beyond what facilities you can manage for smoke-drying. In winter, however, there is no trouble. True enough, drying then is very slow—it is said to take about a week in calm air at 50° below zero to dry a wet cotton handkerchief. But if it is several months before spring, you can split up your meat thick and spread it out on anything—on the snow, on a piece of wood, on stones—and it will be dry before spring, with no possibility of contamination except, as said, that even in cold weather seal, walrus, and whale blubbers become rancid when

exposed to the air. In view of that you must be careful to remove all fat from any pieces of these meats you are drying.

SECTION IV

SOURCES OF WATER

At sea far from land the experienced Arctic traveler uses for drinking and cooking last year's ice, or older.

It can be distinguished from this year's by the rounded corners which are due to the rains and thaws of one or more summers, by looking bluish in comparison with salt ice, which is grayer, and by being glare while salt ice, even a snag sticking upward, is milky in appearance. A further difference, which you learn by experience how to judge, is in the way it splinters when you peck at it with your hunting knife. Salt ice is tougher, splinters less easily.

Ice of last year hardly ever has noticeable saltiness; ice which is 2 years old is probably fresher than average river or spring water. (See discussion in Chapter 2, Section III.)

In summer you are always sure of perfectly fresh water at sea by dipping it up from the hollows in old ice—you are safe unless the pond you are using is so near the edge that spray has dashed into it. Even on this year's ice, which itself is salty, you find in midsummer water plenty fresh enough for drinking—usually so fresh that it will do even for tea.

When the winds are unable to produce much wave action, because the surface where you are is mostly ice, you will find fresh water on top of leads in summer. Stefansson has reported 10 feet or more of perfectly fresh water in a lead resting upon the salt water underneath. These leads keep fresh into autumn so that even a month after the freeze-up you can chisel a hole in the ice, now a foot or 18 inches thick, and get fresh water.

As winter advances, however, the drifting of the ice churns up the ocean enough so that there probably are no fresh leads by November or at most Christmas.

However, the ice that formed in autumn on such leads is naturally still fresh.

In the early fall, fresh water is sometimes found by noting where there is a deep snowdrift covering a hollow in

that paleocrystic ice—which we have described elsewhere and which looks like a rolling prairie. If the snow is 2 or 3 feet deep, you may find, even 2 or 3 months after the freeze-up, that the ice on the pond underneath is only a foot or so thick with quantities of fresh water underneath.

If there is no fresh ice around when you are far out at sea, you may have considerable trouble in getting perfectly fresh drinking water by melting snow. For the crust of salt on top of sea ice gets mixed with the snow in blizzards and drifts with it. However, the slight taint of brackishness is not likely to bother you—it would not be as bad as alkali water common in certain western states to which you are used.

If you are on ice so young that as yet it has little snow on it, then it is almost academic in most cases where you can find drinking water; for you are in so much danger that you are too scared to camp or even to stop for cooking a meal. Such stretches are not likely to be wide, and you will just keep going till you get on firmer ice where there is at least reasonably fresh snow.

On land the Arctic winter traveler will by preference chisel down through the surface of a lake or river till he gets fresh water. It saves a lot of time at camp, and it is a convenience when you are traveling. However, few like to cut through more than 5 or 6 feet. After that you prefer to melt ice.

It is perfectly safe to eat snow when you are thirsty, but most travelers find it pleasanter to drink water. If no water is obtainable, you eat snow or cracked ice during the day to quench your thirst and at camptime you bring indoors chunks of ice which are cut up for the pot as needed.

There are places where you cannot find fresh water or fresh ice. Usually these are on a coast where the ice to seaward is solid and where there is perhaps brackish water in a lagoon on the land side, your camp likely being on an intervening spit, for that is where the driftwood, which you may be using for fuel, is likely to be found. In this case you look around for snow that is granular. The more granular the snow the greater its water content per cubic unit of snow block. The best snow of all is so granular that it will

not even cut into blocks. You bring this snow to the house in buckets or wrapped in a piece of cloth or skin.

There is no trouble about using new, spongy snow except that a lot of bulk makes very little water and also that, because of the air chambers, it takes a little more fuel to do the melting.

Here a caution is worth while. If the snow is extremely spongy and you have a hot fire under the pot, the snow will suck up, blotter fashion, the water which forms immediately over the flame, leaving a cavity there which permits the flame to play for awhile on metal which has no liquid on the other side of it. This is not dangerous with ordinary cooking utensils, but trouble will result if you are using, as Peary sometimes did, a 5-gallon kerosene can for a kettle. In that case the heat may spread out to the corners where they are soldered, melting the solder and ruining the pot.

The thing to do if you are using very spongy snow over a very hot flame is to put only a tiny bit of snow into the pot at first, just covering the bottom. You stand over it with a chunk of snow and a knife in your hand, and as you see melting what is on the pot's bottom you whittle more snow in to keep pace. When you have a quarter inch of water or so, there is no further need to be careful. Then you drop in chunks, but not too large. Only when you have several inches of water is it safe to fill the pot to its rim with the spongy snow.

During the summer there are innumerable sources of pure, fresh water. As explained elsewhere, it is in very few parts of the Arctic, and only in mountains, that you are likely to be at any time several miles from a lake. And in mountains, during the summer, you come upon a river or rivulet every little while. They are numerous though lakes are few.

CHAPTER 9

CLOTHING AND PERSONAL EQUIPMENT

SECTION I

GENERAL

As protection against the weather of their various seasons, the Eskimos have developed on the whole better garments than probably any people in history.

Completely dressed for winter in reindeer (caribou) skin, Eskimo style, you have a suit that weighs less than 10 pounds, all garments counted, inner and outer from head to heel. There are various degrees of softness in the garments according to the age of the animals, but, approximately speaking, every garment except the boots is as pliable as velvet. Nothing feels so good against the skin—not even silk—as underwear of the skin of a young caribou. With these garments you can sit outdoors at $-50°$ and be practically unaware of the temperature, if no wind is blowing. It is commonplace, for instance, even with whites who have never worn such clothes before, to be so comfortable that, quite naturally, they will take off their mittens, pull out a pipe, light up and smoke with no thought as to whether they are doing it in cold or warm weather.

ARCTIC COSTUME

When typically dressed for cold weather in Eskimo clothes, an Arctic traveler wears fawnskin undergarments with the fur in—socks, drawers, shirt, and mittens. The outer garments—trousers, coat, boots, mittens—are made with the fur out, except that the hair side is in on boot soles always and on the palms of mittens usually. The coat goes over the head like a sweater—has no buttons or anything of the sort at the neck.

Of recent years Eskimos in western Alaska, and perhaps elsewhere, have started using zippers. This adoption is probably on a fashion basis, chiefly—the Eskimos see the whites using zippers and want them too. It is Stefansson's opinion, after wearing fur garments every day for 10 winters, that the zipper is no advantage. Whether there is a disadvantage is a mechanical problem that should perhaps be investigated—whether such things as caribou hair and ice from the breath, or a combination of them, can get into the zipper mechanism so as either to prevent its opening or, what would be more serious, prevent its closing again.

Since one of the advantages of the Eskimo style coat is in its being tailored loose, there can hardly be much advantage in the zipper, for nothing can come off more easily than the properly designed coat. There is, true enough, the slight advantage that when overheated you can open up the front of your coat; but, as hereinafter described, most people used to the Eskimo garment will prefer to take it off entirely, for a 2-pound fawnskin undershirt will keep you warm at the lowest calm weather temperatures as long as you are walking or otherwise exercising.

The hood of the coat should not come close around the face. The typical Eskimo style merely covers the ears and leaves the whole forward half of the head unprotected. The first "improvement" that a white man usually tries to make is that of having the hood fit snug about the face. The result, if the hood comes out to the cheekbones and to the point of the chin, is that a circle of hoarfrost forms on the face along the edge of the trimming of the hood, and presently the skin under the hoarfrost ring begins to freeze—or, at least, there is a tendency that way. If the face is completely bare there is

sufficient distance between the nose or mouth and the trimming so that the breath, in very cold weather, freezes in the air on its way to the trimming and settles upon it in the form of hoarfrost, which is dry and can be brushed off.

An important feature of the Eskimo coat and shirt is that the sleeve is cut more like a trouser leg, so that you can slip your arm inside the coat. Then, if one of your hands gets cold, you pull that arm out of the sleeve and tuck the empty sleeve in your belt, carrying your bare hand against your bare breast. If you have to sleep outdoors without shelter, you remove both arms from the sleeves and sleep with them against your breast. You then have all possible body warmth imprisoned inside of your garments.

Both the shirt and outer coat are made so that they hang loosely outside of the trousers and come down about halfway to the knee.

WEIGHT

The entire caribou suit, when made of skins that are ideal as to the age and sex of the animals which contribute (see below), should weigh below 9 and 10 pounds. Outside the furs you may want to wear what are called snow pants and snow shirt, which are made of drilling or of some light and more windproof cloth such as burberry. A "filled" silk or other filled cloth should not be used—it will become stiff in the cold and the filling will crumble out where the garment wrinkles. These snow clothes combined should not weigh more than a pound. They are the only improvement so far suggested by whites that is more of a nuisance than it is worth. On a stormy day they keep the snow from being beaten by the wind into the roots of the hair of the outer furs. Also they contribute materially to warmth. For to the extent that they are windproof they imprison air and, of course, air is the nonconductor upon which we chiefly rely for conserving body heat.

WATER BOOTS UNEXCELLED

It is, however, only the winter clothes of the Eskimos that are near perfection. For the rains and heat of summer they are on the whole not so well clad as we. Still there is no invention of the white man that approaches their water

boots. The sole, though stiff and durable, weighs only an ounce or two; the upper to the knee is as thin and soft as the arm of a woman's evening glove. Yet they are practically as waterproof—the sole, the seams and the legs—as if they were of heavy seamless commercial rubber.

Section II

SKINS FOR CLOTHING

We discuss first skins which are obtainable in the Arctic and sub-Arctic, whether on purchase from natives or as the product of your own hunting.

POLAR BEAR

The skin of the polar bear is used of necessity in some parts of the Arctic and by choice elsewhere. For rough use, trousers of the skin, with the hair out, are perhaps about the best possible. They are not warm for the weight, but they are strong (will last many years if properly cared for), they shed snow, or rather, snow beats out of them easily; and they are to an extent waterproof—what would be called showerproof if they were being advertised by a dealer. They are made knee-length and almost necessarily so, for long trousers of this material would not bend easily enough to permit free movement of the legs.

FOX

A coat or shirt of fox, either blue or white, is certainly very warm for the weight. But, while they keep the hair longer than caribou, the skin proper is so fragile that the clothes need meticulous care. The fur mats, does not stand wetting, and gathers snow. Fox skins are much used by the Cape York Eskimos, probably because caribou is scarce. However, since they are much used, the people know exactly how to handle them and they like these skins because they are used to them.

WOLF

Wolf is stronger than fox and garments made of wolf are nearly as warm for their weight. The objections are the same

as to fox—the matting, the sogginess when they are wet, and the difficulty of beating snow out of them.

WOLVERINE

Wolverine is used by the Eskimos who have access to the skins of these animals chiefly as a trimming material. Hoods are often edged with a band of wolverine fur. The skins are strong and may be about as good as domestic dog for clothing. But northern people have no experience of this, for wolverine is too costly—is used only for trimmings.

BEAVER

Beaver makes a very good coat. The natives use it unplucked, for the long hairs aid in keeping snow from caking, and they shed rain to some extent. A beaver coat will last three or four times as long as caribou, but is heavy—not warm for its weight.

MUSKRAT

Muskrat coats are between good and medium in desirability. They are stronger than rabbit (see below). If you have skins enough for two coats, it would be better to make one out of the bellies and the other out of the backs than to make each coat out of whole skins. The hair is longer on the backs and the skin is stronger. Thus you would use the belly skins for a shirt and the backs for an outside coat. The skins are not as warm as beaver per coat, but they are probably warmer per pound.

SQUIRREL

The Arctic squirrel, or marmot, would come in for about the same remarks as muskrat.

HARE

The skin of the polar hare is so fragile (that of the bush rabbit still more so) that it is to be used only when you cannot get better things. Still, it makes very good slippers, not next to the foot, but in between the first and third layer of footgear. You can manage hare for a shirt if you handle it very gingerly.

OTHER FURS

Coats and other garments may be made out of almost any of the other fur animals, such as otter, marten, and mink. It is most unlikely that you would use marten or mink, for you know their commercial value and, if you had skins, you would, except in dire necessity, save them to bring home because of their market value.

BIRDS

The feathered breasts of certain birds, among them loons and some ducks, as well as sea-birds, make very good slippers to use like hareskin slippers—they are warmer and last longer than hare. Coats are sometimes made of birdskins, but only by those Eskimos who are hard put to it.

CARIBOU

Caribou is the best of all native Arctic materials for winter clothes, and so we discuss this skin more in detail than others.

UNDERWEAR

Underwear—shirts and drawers—should be made of calves anything from a few weeks to a few months old, or yearling females killed before September. Eskimos like underwear of newborn and even unborn fawn. But unborn or very young fawn is so delicate that you should not choose them for yourself until you have had considerable experience in the use of sturdier fur underwear.

For outer garments, coats and trousers, you want fawn from 4 to 6 months old or yearlings, male or female, killed between early July and early September, according to what part of the Arctic you are in—the earlier the spring the earlier the month in which skins are best for clothing. If they are later than September they are even warmer, pound for pound; the chief reason they are not favored is that the hair is then getting brittle. October to December skins are almost too warm for ordinary use; in spite of the coat shedding you may want to use them if you expect to travel as a passenger in a sleigh or in the open cockpit of an airplane. The reasons for the increased warmth per pound are two: As the season

advances the skin, which is the heavier part but not so warmth-giving, grows thinner, while the hair, the chiefly insulating portion but very light, grows longer.

MITTENS

For inner mittens you should have the summer skin of yearlings, though fawn is good if you do not work hard and if your hands don't perspire freely. The hair is inside for the entire hand. Outer mittens should ideally be of the leg skins of yearling or two-year-old caribou; the hair is outside except on the palm and on the inner side of the thumb.

The inner mitten should be to the wrist; the outer mitten may be either to the wrist or with a gauntlet, depending largely on what kind of coat you wear. There is no point in having a gauntlet mitten unless it fits snugly around a somewhat puffy sleeve and the puffiness usually results mainly from the length of the hair on your coat. If the gauntlet does not fit closely, snow gets inside and is a nuisance. Drawstrings are sometimes tried for gauntlet mittens, and are all right if you don't have to take them off frequently.

SOCKS

The socks, with the fur in, should usually be of summer yearling. Slippers to wear outside the innermost socks may well be of fawn skin. They may be of hare, bird, or other skin, but (in this one case in the entire suit) blanketing (duffle) is probably an improvement over any skin.

BOOTS

There is more variety in northern boots than in any other article of clothing.

BOOTS FOR USE ON LAND

A boot much in favor is of caribou leg and comes to just below the knee (as does the sock) where it fastens with a drawstring. Usually the breeches are something like two inches more than knee-length and you tuck them into the top of the boot which grips them by means of the drawstring. But some Eskimos prefer to have no drawstring in the boot,

having it in the breeches instead, the breeches then coming outside the boots. The sole, shoepac type as always, is of August or September bull caribou, and from the back skin. October hides are sometimes used; but, as said, the skins get thinner as the season advances, so that in October they are not quite as strong.

An August or early September bootsole is so durable that on snow exclusively, or on snow and grassland, one pair of soles will carry you a thousand miles at least. However, you need a second pair to change into in order to keep both dry and thus prevent the hair from falling out, as later described.

BOOTS FOR WEAR ON ICE

If you expect to go out on the sea occasionally, where there is slush on top of the young ice, you have a boot as above except that the sole is bearded seal (ugrug) or beluga (white whale)—in emergency you would use the skin of a small seal but it would not keep its shape, be strong enough, or be really waterproof against brine. You may have to use walrus. This would not keep its shape so well as bearded seal or beluga, but is considered fairly good if your soles are cut from a skin that has been used a season in the cover of an umiak—the large Eskimo boat.

If you have a sealskin sole instead of caribou, you will necessarily have to wear more footgear inside. Normally, for a boot wholly of caribou, your entire foot equipment is in two pieces, only the boot itself and a sock of yearling skin. With a seal sole you should have, between the sock and the boot, at least two pairs of slippers—and preferably the outer of these should be of blanket, the inner of fawn or yearling skin. The outermost blanket slipper is advocated both to take up any brine that may enter (possible especially if the sole is from the small seal) and to take up moisture which forms from the condensation of the invisible perspiration (discussed later in this chapter) of the foot against the sole leather.

For winter the Eskimos of interior Alaska prefer a boot of caribou with the hair everywhere inwards. This boot is soled exactly as above described, but the leg, instead of being

made of caribou leg skin, is made of skin from almost any part of the body.

Other boots are described under Seal.

MOUNTAIN SHEEP

The nearest competitor to caribou among the native Arctic skins is the mountain sheep. The warmth-to-weight ratio may be even more favorable than that for the best caribou. However, the skins will then not be quite so durable nor is it quite so easy to beat snow out of them. The preparation and care are the same as with caribou—except that the care is somewhat more difficult.

SEAL

Seal is the most used skin if you take the whole Eskimo world, but in many cases this is from necessity rather than choice. For certain things, however, the skin of the small hair seal (several species) is unsurpassed.

Raincoats are usually made, as later described, of other materials, but sometimes they are of seal. If the garment is purely a raincoat, the tanning (see below) is the same as for water boots. A seal coat with the hair out and not specially prepared is merely showerproof.

OUTER COATS

The hair seal is not suitable for underwear at any season. For an outer coat with the hair out, the skin is good for weather that is not extremely cold. This garment is less warm for its weight than any we have so far described, but makes up for this partly by being the strongest of all materials, by being water-resisting, by the ease with which it sheds snow, and because it stands most kinds of rough treatment better than any other skin. This includes getting wet and staying wet, although no skin is really proof against much of that—the hair of all of them begins to drop off.

TROUSERS

For trousers, worn hair out, the seal has the same advantages and disadvantages as for a coat.

ALL-SEAL WINTER BOOTS

A very good all-round winter boot is of seal skin, hair out for the leg, and bearded seal or beluga sole. If the sole is bearded seal it may or may not have hair against the foot, usually not; if whale is used there is, of course, no hair. If all materials are available, this is the type usually chosen by hunters who cultivate the sea and frequently have to deal with the slush on young ice.

SUMMER WATER BOOTS

The ideal material for summer water boots is: for the sole a piece of bearded seal skin that has been in use for 1 or 2 years as part of an umiak cover; for the upper, the skin of one of the smaller species of the small seals—in northern Alaska and northwest Canada the *Phoca hispida*. This is black or dark brown in color, having been prepared merely by removing blubber and hair (as described later) and then by simple drying.

Substitutes for the ideal bearded seal sole, in descending order, are white whale, walrus and the skin of a very old male of one of the small seal species. In emergency you will use the hide of the back of the neck of a full-grown caribou bull or some thick part of musk ox hide. With the last two greasing is required, for those skins are more porous.

The thickness of the upper is controlled partly by choosing the age of your animal and partly by using back or belly. There are effective water boots made with upers so thin that when you hold them up against the light you can see clearly the outline of your hand pressed against from the other side. When slightly damp, as they must be before you put them on, the uppers of these boots are as soft as the finest kidskin. The sole is stiff and keeps its shape even after many weeks of wearing—especially, as said, if it comes from an old umiak cover, and if it has been well crimped (see below).

The reasons for the waterproofness of Eskimo boots and directions for the care and use of such boots are set forth later in this chapter.

COMMERCIAL BOOTS

For certain kinds of rough work, as around mines or in digging ditches, commercial water boots are better than the Eskimo. These will be in Alaska of the kind tried and tested by prospectors and miners. Representatives of the Army should try these out on the ground, at some such place as Fairbanks. We do not, therefore, attempt either a description or suggestions here.

There are possible a number of temperate zone substitutes for Arctic skins.

DOMESTIC SHEEP

Doubtless the most important southern competitor of the reindeer (caribou) in northern clothing is the domestic sheep. The advantages are abundance of supply, cheapness, durability, and comparative resistance to grease, the last making them specially suitable for use of mechanics. The chief disadvantage is that sheep is not nearly as warm as caribou for its weight. A further drawback, until better tanning processes are developed, is that sheepskin stiffens in cold weather.

Since lightness and pliability are not very important except for those who have to walk long distances, or who may have to do so, it would seem likely that in the beginning at least most skin clothes used by the Army for Arctic and sub-Arctic work will be made of sheep. We withdraw from application to them our possible objection to zippers, above; for sheepskins are likely to be worn chiefly in a forest where fires can be made and where icing of zippers would not be so serious.

Eventually there will perhaps be a seasonal issue of clothing so that even those who, in the long run, are best served by caribou skins for midwinter will use sheep in spring and autumn. However, the economy of doing this is lessened in that caribou skins, although they keep their hair well for a single year and with good care are suitable for two years, will not keep it satisfactorily for much more.

FUR SEAL

A commercial skin worth considering for winter clothing is that of the fur seal. Its advantages and disadvantages

are probably about the same as those of beaver, discussed above. Like beaver it should be used unplucked.

SECTION III

ESKIMO CLOTHING

a. Procurement

The perfection of Eskimo garments comes through the skill of the maker rather than through special processes. It is, therefore, difficult to give helpful instructions in a Manual. There are, accordingly, only four ways in which to provide yourself with Eskimo clothes.

The ideal way is to discover a family in which there is on hand, already made for one of its members, the garment you want and of the size you need. This is not so difficult as it might seem, for these clothes are all loose fitting—they must not be too small but it does little harm if they are a bit on the large side. Were it the plan to make them in lots of thousands (for the difficulty of which, see below) they would not need to be in more than three sizes, except for the boots which should perhaps be in almost though not quite as many sizes as the ordinary Army footgear.

The reason why it is best to purchase a garment which was intended for a member of the family is that the best are made only under two stresses—loving care and the knowledge that the maker is going to be criticized if defects appear.

The only way to secure a near approach to the same care in the making of clothing as a member of the family gets is to employ the requisite number of Eskimo families by the year, giving each seamstress the job of clothing a certain number of men and of looking after their clothes while they are within reach or of repairing the clothes when the wearer returns from a journey. They will look upon the men assigned them to clothe more or less as if they were members of their families. Very good results can be secured in this way, especially after some years when you have had a chance to coach for awhile those seamstresses who have not given the best satisfaction and to discharge any who may prove incurably careless or incompetent.

It is possible that tolerable results can be got in places where there are large Eskimo communities near you by having a certain number of your men assigned as regular customers to a given seamstress. She then knows they will come to her with complaints and that she will have to keep in repair the suits she makes.

The fourth method is the one that most white men have used in the Arctic, particularly in Alaska—just to buy clothes that have been made to sell. The results here are best when you inspect carefully each garment as it is brought in for sale. They are worst when you let it be known that you want a certain number of suits by a certain time.

The inadequacy of the fourth method, from the Army's point of view, is increased by the difficulty there would be in finding local white men to give advice on what clothes were up to a reasonable standard. For not many white men in Alaska (the exceptions being perhaps a third of those who have Eskimo wives) know what a good garment is. They have never had any good ones themselves, although they have been using Eskimo clothes for years, and they have never noticed the difference between the inadequate clothes which they have been wearing and the good ones that were being worn by some Eskimos.

The badness of the best clothes that Nome Eskimos make for sale results from the following main things: The skins are not of the right age and sex for the intended garment; the animals were not killed at the right time of year; the skins have been hastily and poorly sewn.

We must not overstate the case against clothes secured by the fourth of our plans. Polar expeditions, notably those of Admiral Byrd, have been outfitted by this method. It seems to explorers used to better clothing that being so dressed must be a handicap, if not a hardship. But men of the Byrd expeditions seem to have complained very little. They did good work in what to them evidently seemed reasonable comfort.

Garments like those supplied to Byrd have been worn since 1900 by an aggregate of thousands of different white men and white women around Nome, and generally on the Bering Sea coast of Alaska, usually with satisfaction to the wearers.

While the clothes have fallen below Eskimo standards, they nevertheless proved on the average beyond, or at least up to, the expectations of the white purchasers.

With all its drawbacks our fourth plan will probably have to be used if the Army wants large quantities of Eskimo style clothing. It will be necessary, then, to have for adviser to each purchasing agent a white man who, from having worn them through several years, knows what it is that makes good Eskimo clothes. The Eskimos themselves are, of course, even more competent judges; but it is difficult to find one of them who is willing to act as arbiter and to give, when called for, adverse opinions on the handiwork of his people. The next step will be to impress upon all Eskimos planning to submit garments for sale that they are going to be inspected by an expert and that clothes will not be accepted unless they pass his scrutiny. Alternatively, the Eskimos could be informed that garments will be graded into first, second and third class; that there will be a considerable price difference between the grades, and that whatever is offered for sale will be inexorably graded by the said competent expert. If some such procedure is rigidly followed it ought not to take many years until there have been developed in Alaska several hundred competent preparers of skins and cutters and sewers of garments.

b. Preparation of Skins

The following description of the preparation of skins is intended to give an understanding of the processes rather than facility in their use. However, preparing skins is not a fine art comparable to the making of the garments.

It is a loose expression, or a result of careless observation, to say that Eskimos "tan" caribou skins intended for winter clothes. True, certain processes which are fairly called tanning have crept into Eskimo territory from here and there—from the forest Indians chiefly, although in places from whites. Most if not all of these result in one or both of the drawbacks that the skins are stiffer and that they smell stronger.

The steps in the best preparation of caribou for garments are only three or four.

PRELIMINARY STEPS

Immediately after the animal is skinned, you spread the hide on the ground, flesh side up, or you hang it similarly over a pole. The drying preserves the skin until you want to use it.

For the first stage of preparation you work on a skin which either happens to be bone dry or which you have just dried by suspending it far from a fire—about twice as far as an inexperienced man would consider safe, for caribou skins spoil with ease difficult to believe. They should hang where the direct heat from the fire is just barely perceptible on your hand or cheek.

FIRST STAGE

Taking the dry skin, you sit so as to hold it conveniently over your leg above the knee. Another thing you can do is to spread the skin out on your caribou bedding or on any fairly level soft and reasonably flat surface. With a resilient softness underneath, you scrape the flesh side with any dull scraper. Those of flintlike stone are very good but of recent years Eskimos have preferred scrapers of brass, iron, or steel. One kind they like is made of a short section of a 10-gauge shotgun barrel, the edges sharpened but not to razor keenness A portion of a brass shotgun shell will do. An iron piping somewhat larger than 10-gauge is better. Sometimes they split the pipe so as to use only half, and there are other scrapers of various curvatures. In other words, practically anything will do.

When all the facia has been scraped from the hide, you dampen the skin slightly and hang it up, again remote from the fire, till it is thoroughly dry. Then you scrape again.

SECOND AND SUBSEQUENT STAGES

The process of scraping, dampening, and drying is repeated until you think the skin sufficiently soft. In the case of young fawns one scraping is usually enough. With yearlings two scrapings usually suffice, the first rough one and the second after the skin has been once dampened and then dried.

It is customary with Eskimos after the first scraping to dampen the skin, roll it up, and let it stay overnight in some

place where it will not freeze but is nevertheless fairly cool. Whether this is necessary is doubtful. The dampening must be so light; the hair must not get soaked when you roll up the skin—in that case it might rot loose from the hide.

RESULTS

A caribou skin that has been prepared with nothing but scraping, as above, is white in color and practically odorless. If you want to change the color and give as well what most whites think is an agreeable odor, you smoke the skin. The woods Indians do it by merely hanging it far enough from the fire in the place where they do their cooking, letting it stay there for a few days. Doubtless the same result can be attained more quickly in a smokehouse built and used in the style of farmers smoking meat—again with caution against overheating.

The smell of Eskimo caribou clothing, though frequently objected to when they are brought into city homes, is not necessarily disagreeable to everybody, even at first. For instance, both Colonel and Mrs. Lindbergh said they liked the smell the first time they used or handled Eskimo clothes, and Mr. and Mrs. Rockwell Kent gave the same testimony. Those who object to the smell, at least in some cases, do so apparently from a preconception—they seem to feel it is expected of them.

COMMERCIAL PROCESSES

There may be commercial processes now which produce skins as good for clothing as the scraped Eskimo, but none could be found between 1889 and 1906 during the heyday of the American whaling fleet in the western Arctic, when whaling captains went so far as sending skins to Europe for tanning. However, the best of the processes had only one serious defect—that the commercial tanned skins, although soft as Eskimo style in warm weather, stiffened with the cold. The Eskimo preparation keeps them as soft at $-50°$ as they are at $50°$.

FOREST INDIAN PROCESSES

Woods Indian ideas, such as rubbing decayed caribou brains or decayed liver on the skins (a process adopted by some

Eskimos) results in a strong odor, unpleasant to many whites, and, what is more serious, produces the same sort of stiffening with cold weather that resulted from commercial tanning.

SKIN FOR BOOT TOPS, GAUNTLETS

As described, one type of winter boot has the uppers from the leg-skin of caribou, and long mittens may have leg-skins for the gauntlets. Stiffness is here a merit and so leg-skins are scraped only enough to take out all the wrinkles that may have resulted from drying. If the piece is intended for socks, it is scraped as soft as any other part of the hide.

SKIN FOR BOOT SOLES

Also for the sole of a winter boot you scrape just enough to take out the wrinkles. The skin you want for this is from the back of the neck of a bull caribou killed when the hair in that part is about ½ or ¾ inch long, which might mean anything between early August and late September, according to where in the Arctic the animal is killed.

BULL HIDES FOR BEDDING

Commonly it is not wasteful to take the necks off your caribou hides for this purpose, since doing so makes them a better shape for bedding, and that is the chief role of bull hides. For that use they are either scraped merely to remove wrinkles or left quite unscraped.

If you are short of the right kind of skins for boot soles, you may get other pairs from the hide along the back, the next best being from the shoulders and possibly even from the rump.

If the hair is more than ¾ of an inch long, you can, so far as the hair itself is concerned, deal with the situation by clipping. But what you cannot help is that as the hair lengthens the skin gets thinner, so that if your bull has hair 2 inches long on the back of his neck, his hide is no longer ideal for boot soles.

It is sometimes said that Eskimo women chew these soles to make them soft so they can be given the shoepac shape. It is more correct to say merely that the soles are crimped into the required shape by biting with the front teeth. (This

is not the beautifully regular full crimping of the soles of water boots; it is, in fact, more a wrinkling or puckering of the edge of the sole.) Certainly the bootmaker has no conscious object of softening the leather—the stiffer it is the better, for what you desire is that the boot shall keep its shape, which is attained partly through the stiffness of the leather itself though partly by designing the boot so that the upper tends to hold the sole in position.

Sometimes, for want of hide that is stiff enough to need crimping, the soles of your caribou-leg boots are just bent by hand into approximate shoepac shape.

INLAND TYPE OF BOOT

The inland type boot never has a crimped sole. Either just from custom or because footgear wears out less quickly in most places inland, the back country Eskimos use thinner skin for their boot soles. If they know they are going to have to travel over rocky ground they use underneath the heel and the ball of the foot round patches of some heavy leather, frequently sealskin which they have bought from coastal people—otherwise neck skin of bull caribou from which the hair has been scraped. This sewing is with stitches that do not, or at least preferably should not, go all the way through the sole leather.

PREPARATION OF SMALL SEALSKINS

The preparation of the skins of the small seal (any of the ordinary northern seals except the bearded) for coats, trousers or uppers of boots is essentially the same as with caribou. What you have sticking to the flesh side of the skin, however, is not fragments of lean, as with caribou, but a little blubber. For that reason you begin by wetting the skin and then, holding it over your knee, shaving off the blubber with a very sharp knife. Next you dry and remove the last vestiges of fat by rubbing with something like sand or ashes. Now you stretch the skin to dry, preferably out of doors—it will dry in a day in summer or in a week in winter. Eskimos frequently peg out the skins on the southward face of a snow wall, in some cases a wall erected for that purpose.

When the skin is thoroughly dry, you scrape as with the first caribou scraping.

REMOVING HAIR

In dressing seal and walrus for use where no hair is wanted, as for waterproof boots or for boat covers, you first remove particles of flesh and fat as above. The skin is then rolled into a bundle with the hair side inward and kept in a warm place until sour and the hair loose. Small seal skins are sometimes dipped in hot water to hasten the loosening of the hair.

When loose, the hair is scraped off and the skin is stretched on a wooden frame, made from sticks of driftwood, by stout cords passed through slits around the edges and over the side bars of the frame.

WHITE TAN

The beautifully white, parchmentlike leather used for dress boots and ornamental work is made of small seal skins from which the hair has been removed. The skin is then soaked in urine to free it from the oil, stretched upon the drying frame and exposed in the open air during the coldest months of winter; the intense cold and the beating of the dry snow upon the surface of the skin bleach it to a satiny whiteness.

c. *Use and Care*

No grease should ever be rubbed on the upper of a well-made sealskin water boot or into any seam—the only greasing theoretically permissible is for the outside of the boot-sole, in case the material is second-rate and inclined to be porous.

Among Eskimos there are two reasons why you must not grease a seam. If the woman who made the boot, her friends or relatives, see you doing it they take it for an insult—a sign that you do not have confidence in the workmanship. The second reason is that, in Eskimo belief at any rate, greasing shortens the life of the boot. Almost certainly it is true, as they say, that you need even more care in drying a boot after it has been greased than before. There is a further difficulty if the boot has been greased: Some of the oil will get into the sinew and will prevent it from expanding

properly, a necessity for making and keeping the seams watertight.

However, it is usually necessary to grease these water boots that have been made to sell—ones, for instance, you purchase in a shop at Nome. The "civilized" local Eskimos do not mind seeing you greasing those; they don't take seriously garments which have been made to sell and they are getting used to white men's views and ways. It is hard to restrain a white man from greasing a boot.

A SPECIAL TYPE OF SEAL BOOT NEEDS GREASE

We have seen that seal boots well made out of stock rightly prepared should not be greased; that if shoddily made from good stock they have to be greased at the seams. But sometimes water boots are made of sealskin not originally intended for water use. Then not only all seams but the entire boot have to be greased.

For certain uses a boot of this last type is best. The Eskimos do not have any way of so preparing sealskin that it retains the hair and is also water excluding. But there is warmth in the hair; during spring and autumn you need warmth in your boots as well as power to keep your feet dry. To meet that condition a boot is made with a sole of waterproof bearded seal, or one of the substitutes, and an upper of the fairly heavy skin of a mature small seal. The hair is turned in; the outward facing skin side is greased at least twice. After the first greasing the boot is hung up to dry for a day or two, preferably outdoors in the shade. A second greasing is applied just before the first time the boot is worn.

CARIBOU WATER BOOTS MUST BE GREASED

In spring and autumn waterproof boots are needed inland and it may be that the only material available is caribou. The uppers are then greased just as we have described for the seal boots that have a hair side in towards the leg. It is hard luck if you have to make the sole of the inland water boot also of caribou. If you must, you use the thickest skin you can find, no doubt from the back of the neck of an August- or September-killed bull caribou, and grease it again and again with the best fat available.

It is considered that the best oil for greasing leather which is not otherwise waterproof is seal, and new seal oil is considered better than rancid—it is stickier, forms a better waterproofing. Whale and walrus oil are next best. If you are inland you use as a substitute the fat from hoof bones and those just above the hoofs of caribou, mountain sheep or moose, the equivalent of our neat's-foot oil. Tallow of the northern herbivorous animals, or our beef and mutton tallows, are passable waterproofing in warm weather; but they are not good in winter for the grease coating breaks and the ingredients fall away where the boot creases. Lard is medium good—it is much better than tallow but not as good as an oil.

A makeshift waterboot can be made of canvas with sole of bearded seal or one of the substitutes. The canvas must be fairly heavy. The best greasing here is lard—if you grease a canvas upper with seal, the oil will keep working through into your socks; whereupon they cease to be nonconductors and your feet are in danger of freezing.

CARE OF LEATHER USED IN WATER

The main principles in the care of all water gear made of skin—among them clothes, boats, leather water buckets—are: Be careful they are kept dry when not in use; dampen them a little while (say, ten minutes to half an hour) before use; don't let them stay wet continuously long enough for bacterial breakdown (not more than two or at most three days); dry them carefully.

The technique of drying and dampening of water boots needs special description because they are the most delicate and special conditions apply.

The rate of bacterial action upon rawhide depends on degree of warmth and uniformity of warmth; it may depend also on salt in the water. It would appear to be for both chemical and physical reasons that a water boot will last longer if you use it in salt than fresh water—the salt water is likely to be colder, inhibiting bacterial action, and the salt itself kills many bacteria. A boot used in fresh water, then, decays more rapidly because it is warmer and because the bacteria which flourish only on the inside of a boot used in sea water flourish on both sides of the leather with fresh water use.

The warmth which promotes decay in a boat is furnished by the weather and the water. In the case of a boot there is an additional source of heat, the warmth of your foot.

ON JOURNEYS CARRY SPARE BOOTS

You start a journey with boots which are either new or which have been so dry since they were made that you know there can have been no bacterial action. You are very careful to keep dry all spare boots. For the pair you are going to wear tomorrow you do one of two things: If you expect to have to start traveling the moment after you awaken, you dampen your boots in the evening. This is best done by taking each boot separately, holding the mouth of it tight so no water can enter, and thrusting it completely below the surface of water. Pull it out after a moment's immersion, let it hang till dripping from it ceases, then roll it up and put it where it will be reasonably cool, as, for instance, underneath your bedding. If you do not expect to travel until half an hour or more after you wake up, you dampen the boot, as above, the first thing in the morning. You can put it on immediately, if you like; or else lay it aside while you are breakfasting. In either case, the sinew thread swells so that the seams of the boot will be waterproof when you start to travel.

EMERGENCY DAMPENING

If, through emergency, you are compelled to put on dry boots, then you watch for your first opportunity and thrust your foot for a fraction of a second into water almost to the top of your boot, pulling your foot out before an appreciable amount of water has had time to trickle through the seams. If, after this, you can walk 15 minutes to half an hour before beginning to wade, you will find the boots giving you full protection.

In summer the best way to dry boots is to hang them in the air, whether sun or shade does not matter except that sun dries them quicker. Take the boot down when it is dry rather than shrivelled. They may be packed either by folding the upper round and round the sole or, better still, by folding the leg, accordion-fashion, so that it fits inside the sole of the boots.

If you dry by use of a fire, you must be even more careful with water boots than with winter clothing to have them far enough from the source of heat. Take as a rough standard a kitchen where cooking is being done on an ordinary old-fashioned range. Winter skin clothes should not be closer than 6 feet from such a stove, and water boots should be at least 10 feet away.

On the third Stefansson expedition a lot of water boots were ruined by sailors who hung them 3 or 4 feet away from a stovepipe. Their excuse was afterwards that they had noticed hardly any appreciable heat from the pipe.

These directions should not be misunderstood to mean that it is almost impossible to keep skin boots in good condition. All we mean is that you must be very careful. This care becomes second nature after awhile—you take the right precautions almost without thinking.

It follows from the above that you must have two or three pairs of water boots for summer travel. When the weather is dry two would be ample; the third is a precaution against rainy spells. Our statement that each pair can be worn a maximum of 3 days at a time without drying is on the assumption that you always take them off when you camp. If you sleep with them on, or have to wear them day and night for any reason, the maximum period between dryings will be reduced to 2 days or even less.

The period during which a boot remains dry need not be long—just long enough to kill the bacteria by desiccation.

With proper alternation and care, the uppers will last longer than the soles, for there is practically no wear on them. The soles will last through a 4-months' summer if you do not walk much on stony ground. As explained for winter boots, you take precautions against stones when necessary by sewing large roundish patches under heel and ball of foot, these to be replaced when worn out. Approximately speaking, then, an outfit of two or three pairs lasts you through a season—even with continuous use, as, for instance, if you are the caribou hunter of a party and average 20 miles of walking per day throughout the summer.

The waterproofness of the best Eskimo sealskin boots depends on two things, the skill of the sewer and the use of a sinew thread that swells enough on being dampened to fill all needle holes.

TESTING A BOOT FOR WATERPROOFNESS

If you are compelled to use water boots not made by someone practically a member of your family, you should before purchase test them as good seamstresses do when they are making them. The shopkeeper naturally shows you a dry pair. Before accepting it, dampen as above, and wait at least half an hour. Then take the soft top of the boot in your hand, somewhat as you might a paper bag, blow until you have completely inflated the boot, and then give a twist so as to confine the air. Press and increase the pressure steadily till the boot is smoothly inflated at every point, then pass each seam along near your cheek so as to try to detect the escape of air. A more delicate way is to have a candle burning steadily and pass the seams of your boot near the flame—being careful, however, not to hold any spot very long near the flame; for we repeat, it is incredible to most people how a little heat will injure this type of leather. A still more conclusive and a simple way is to hold the inflated boot under water and see if any bubbles arise.

If the least bit of air does escape from a boot that seems to be of good workmanship, you might give it a second break. Dampen additionally the seam where the air has been escaping, wait a quarter of an hour and try again. If the air still escapes, the seam needs resewing at this point. If that is not attainable, you dry the boot, and grease the untrustworthy seam before you wet it again preparatory to wearing.

Short water boots, or slippers coming a little above the ankle, may be of use around camp, sort of as bedroom slippers, in damp surroundings. For other use you want a boot which comes at least to just below the knee. There it grips your leg tight with a drawstring. Ordinarily this is just tight enough so that if you were to slip casually into water for a moment a little above the boot top no appreciable amount would get in.

TIGHT DRAWSTRING MAY PRODUCE VERICOSE VEINS

But it may be that you have to wade all day in water that comes above the knee. Here a difficulty arises—there certainly appears to be at least a small danger of the development of varicose veins through such extremely tight lashing as is necessary if you want to keep all water from entering during an all-day wade. That you will have to take this small chance is not to be taken as granted, for you cannot in any case keep your feet dry all day, no matter what footgear you use. In the angle we are just going to present, your feet get wet even sooner in a sound rubber boot than in a well made skin boot.

NO FOOTGEAR WILL KEEP FEET DRY IN SUMMER WADING

There is ice water outside your boot and your foot and leg are inside of it. From every part of your skin there is emerging the invisible perspiration (discussed later). This is bound to condense against the chilled material. For some time your woolen or other fabric socks will absorb this; but long before evening your feet are going to be distinctly wet. We said this condition was even worse in a rubber boot. This is because that material is a better conductor than leather of the chill from the water. (In cases where feet are actually kept dry inside rubber boots, if such occur, this must be because they are open at the top, allowing the escape of moisture, which would not serve if the water in which you travel is over your boot tops.)

On the Stefansson expeditions the men were given their choice about tight lashing of boot tops, the risk having been impressed upon them. Some excluded all water the whole time with tight lashing. Others lashed so that the water trickled in very slowly. The difference between this and having it come in fast is that your foot warms up the confined water so that you are in effect wading in warm water all day. In cases where water was permitted to enter, the boot, of course, had to fit rather tightly against foot and leg. Otherwise the man would have had to lift a considerable weight at each step.

There were from the various Stefansson expeditions only one or two cases of the development of slight varicose troubles. It is even possible that these may have had another origin, although the men did blame them on the tight lashing.

Though you walk all day across a swampy northern prairie in Eskimo boots your feet will keep dry unless they perspire. For the water you step into is more or less warm and the immersions are only occasional, so little or no inside condensation need occur. It is only during summer travel on sea ice that you have to wade say two-thirds of your traveling day through water ranging from ankle to knee-deep. That you do seldom have to wade through deeper water is because of the standard thickness of sea ice. When the puddles on top of it begin averaging more than eighteen inches deep the ice is no longer safe for travel. As elsewhere explained, you must be ashore before the thaw proceeds that far, or else you must select a good heavy floe on which to camp and spend the summer, resuming your travel in the autumn.

SEMIWATERPROOF BOOTS FOR SEA ICE TRAVEL

In dealing with slush ice you should be wearing preferably boots with soles of bearded seal and legs of small seal with the hair in. (Regular summer water boots are too cold; full deerskin winter boots will get wet through.)

Or, also very suitably, you could use the intermediate form which has a bearded seal sole with an upper of oiled caribou skin with the hair in.

HIP-LENGTH WATER BOOTS

Seal water boots are sometimes made to the hip by Eskimos for their own use, and frequently for whites. They are best for such semisedentary occupations as duck-shooting or fishing. They did not win favor on the Stefansson expeditions, for in most cases such boots remain dry up around the knee and are therefore stiff enough to interfere appreciably with knee action.

INSOLES OF MOSSES AND GRASS

If your socks are insufficient, especially if your boots are large and with thin soles, you can do well putting moss into

the sole as a pad. Dry grass is used for this, too, and good results can be had with no socks at all—with your feet bare inside of the boots and with enough grass or moss between them and the sole.

The chief disadvantage of feet bare except for moss or grass is that you cannot then deal with hoarfrost very well by the methods outlined in Section IV of this chapter. A compensating advantage is, however, that you can throw the grass or moss away when it gets full of hoarfrost, or soggy, and use new material. This applies more or less even if the journey is across sea ice, for you can provide yourself with a bag of moss or grass before leaving shore. On an Arctic prairie you can find as you go along grass that will do for insoles.

The advocates of grass as an adjunct to Arctic footwear sometimes claim that it keeps your feet warm by bacterial action—by the heat of fermentation.

WATERPROOF COATS

Waterproof coats are sometimes made of skins prepared as those for uppers of water boots. More often they are made of the dried intestines of large animals, slit lengthwise, the strips arranged vertically in the garment. For waterproofness the sewing thread used ought to be sinew.

KAYAKER'S COAT

A special variant of the waterproof coat is used by kayakers, chiefly in Greenland and Alaska. The garment is hooded, with a drawstring pulling it close around the face so that very little water can get in. It is also tightened at the neck, so that, if any water does get by around the face, it will not go farther down. Tight lashing at the wrists prevents water entering there, and the bottom of the coat is lashed around the mouth of the kayak. Man and kayak are thus in one water-excluding piece. (See Chapter 12 for discussion of kayaks and their use.)

So far we have dealt chiefly with ways of caring for skin boots; we now turn to the other garments which constitute an Arctic costume.

A first essential in the care of garments to be worn in cold weather is that they shall be kept free of grease. On the well-known principle which we have mentioned several times, that the warmth of a garment depends on air chambers, it follows that if grease fills the chambers the insulating qualities of the material are greatly decreased; for grease is a good conductor of heat.

At the time of the mishap it is equally bad to get the air chambers of your garments filled with water or with grease. But getting wet is less serious in the long run; for the water can be removed by a simple process of drying, while removing grease is not simple under the best of conditions and may be in practice impossible when you are on a journey.

All northern travelers should, therefore, acquire the point of view of the Eskimos with regard to grease. Those of them who are not sedentary, and whose culture has not been too much influenced by whites, are as careful to see that no grease gets onto a winter garment as a meticulous housekeeper is with us to see there is no dust on the furniture. There is a difference between dust with us and grease with them—dust in a house need not be more than a sign of untidiness; grease in winter clothing can be a matter of life and death.

It follows from what we have said that nothing can be more silly than what we hear occasionally about Eskimos keeping warm in winter by greasing their bodies.

We mentioned the idea of some whites that frostbite may possibly be retarded by heavy vaseline greasing of the face. We pointed out there and repeat here that even if vaseline did serve as a face protector, it ought not to be used, nevertheless, for it would be nearly impossible to keep some of it from getting into some part of your clothing.

Other suggestions for the care of both the outer and inner garments of a skin suit, and for the care of skin sleeping bags, have chiefly to do with preventing moisture from getting into them, not only the moisture that may come from contact with snow, ice, and water, but that which results from visible and invisible perspiration. This is a special northern problem, requiring special explanation. We therefore treat in the following section the further precautions involved.

SECTION IV

PROTECTION FROM VISIBLE AND INVISIBLE PERSPIRATION

a. Statement of Problem

The problem and technique of how to keep winter clothes dry hinge upon there always being an "invisible perspiration" coming out of the human body—a vapor invisible at ordinary temperatures but visible even around $-30°$ or $-40°$ and becoming rapidly more conspicuous as temperatures drop towards $-70°$, $-80°$, and $-90°$. If you hold out a dry hand at $-50°$ or colder you will see a cloud of steam rising from the palm and wisps of steam from the fingers. Added to this as a source of moisture is, of course, the ordinary, visible perspiration caused by exertion and too-warm clothing. The combined moisture of the two perspirations condenses somewhere in the garments in the form of hoarfrost.

In cold weather the dew point, or point of condensation, is reached in the second or third layer of clothing where the cold from the outside meets the warm "steam" and turns it into hoarfrost. If only two layers of clothing are worn, it may be at $-20°$ that the dewpoint is reached outside of the second layer and that all frost will either float away on the air as a fog or gather exclusively on the outside of the outer garments, where most of it can be brushed off. But if the temperature drops another $20°$ or $30°$, the condensation will begin to take place between the two layers. Then, unless necessary precautions, as outlined below, are taken, there will be a melting if the temperature later moderates or in the warmth of a camp. Later, on being exposed to the cold, the dampness turns to ice.

To illustrate: If, wearing three-ply mittens, you walk in cold weather with your hand unclenched for several hours and then clench it into a fist, you will soon feel dampness against your palm and between your fingers, while the back of your hand still feels dry. You have melted the rime which had gathered between the layers in the palm of your mittens, while on the back of your hand the hoarfrost is still hoarfrost. Now open your hand; presently the palm of your mitten will

be stiff while the back remains flexible. Take off the three-ply mitten, separate the layers, and you will find that you can shake or beat the hoarfrost out of every part except the palm. There a shaking or beating process is of no use because the dry and powdery hoarfrost has first been liquefied and has later had a chance to freeze into ice.

b. Procedure in Camp

The problem of garments thus becoming damp from visible and invisible perspiration, and of growing constantly more wet during travel at low temperatures, was stated by Nansen as being insoluble. The dangers and inconvenience which result from a failure to follow the proper procedure when in camp can be illustrated by his experience.

Nansen and his one companion, Johansen, traveled during the cold days dressed in several layers of clothing, with hoarfrost forming in one layer or another. They camped at evening by pitching a tent, inside of which the temperature would possibly be $-10°$ against say $-40°$ outside. None of their clothing was removed. The change of temperature between outdoors and camp was enough to shift the melting point in the garments—the hoarfrost lodged in the middle of the three layers would melt, making that layer damp, some of the moisture reevaporating and condensing over again in the outside layer. If any passed through the outermost layer without condensation it would rise and condense against the canvas of the tent, where would condense also the breath of the campers and the steam from cooking.

The Nansen-Johansen sleeping bags were of several layers. When, fully clad, they crawled inside these bags they began to get wet. A very little of the moisture was from snow which had adhered to their clothing accidentally; most of it was from hoarfrost which now melted in various garments.

What reevaporation there was during the night condensed in some layers of the sleeping bag, to remain as hoarfrost only till the sleeper turned over so that what had been above him was now underneath his body. Then the hoarfrost became liquid.

The first morning Nansen crawled out of his bag with damp rather than wet clothes. Little of that moisture

evaporated during the day, while he was accumulating as much again in the form of new hoarfrost. After the second night in his sleeping bag he was nearly twice as wet; after the third nearly three times, and so on until, after some weeks, the bags weighed several times as much as they had in the beginning, the difference being ice.

Because of the melting due to his body heat, Nansen slept, he says, in the equivalent of an ice-water bath every night. When he got up in the morning he did not dare to permit the sleeping bag to freeze crumpled up. So that he might be able to get into it at evening it had to be kept straight to freeze rather like a barrel. He was forced to be even more careful with his own clothing. He took hold of the sleeves and stretched them while they froze, being similarly careful with his trousers. He kept bending his body, elbows, knees, and hips, so that there would be joints to permit movement. When the freezing was complete the clothes worked somewhat like medieval plate armor. They were almost as hard as metal. Nansen tells that the edge of his frozen sleeve cut his wrist so that he would carry the scar to his dying day.

The Nansen type of difficulty becomes serious only on long cold journeys where there is no chance to dry your clothes by a fire. During such weather it is advisable to use snowhouse camps, which Stefansson's parties normally did. Their clothes, as said, were caribou—underwear with fur in; outer garments with fur out; outside of these the snow shirts and snow pants of drilling, khaki, or gabardine.

To outline the procedure, take for example an extremely cold day, of fairly light work, when the members of the party are wearing three suits (total weight, furs and outer cloth garments, 11 pounds).

PREPARATION OF BEDDING

With the snowhouse erected, the cook of that day goes inside and the bedding is handed in to him. The first skins are to be the lowest and they are laid fur-side down on the snow. It does not matter how much snow clings to the fur side of these bottom skins, for it is never going to have a chance to melt. All the housekeeper does, then, with the first layer is to brush the snow from the top or skin side.

The second or top layer of bedding will be skins placed with the hair up. At low temperatures snow and hoarfrost are as dry as the dryest dust. The housekeeper beats off the fur side and brushes off the skin side before putting the top skins in position.

The snow platform underneath the bedding is now covered with a double insulation so effective that, even if you bring the temperature of the dwelling later to 50° or 60°, there will be no chance for the lower layer of skins to get wet by the metling of the snow underneath.

The third stage is to bring in the sleeping bags—of one thickness and with the fur short, for a reason which will appear.

Standing in the low part of the house in front of the bed platform, the housekeeper now peels off his outer garments. He gives each a perfunctory shake as he takes it off and then puts it down on the floor or into the alleyway. For, as said, no amount of hoarfrost or snow can make a garment wet unless it melts, and the temperature in front of a bed platform will remain far below freezing.

The housekeeper is now dressed in one layer of clothing, his light reindeer skin underwear. There may be a little hoarfrost on the outside of this, which he brushes off. There can not be any inside the underwear, for the body warmth during the day has prevented invisible moisture from condensing that close to the source of heat.

The housekeeper has entered a cold house which he later warms up with a fire—hence the above procedure. The rest of the party will enter a house already warm. Accordingly, they take off their outer clothes either outdoors or in the alleyway. They handle them carefully if they want to bring them into the house (beating off all hoarfrost and snow), or shake them casually if they are going to leave them in the alleyway.

The frost can be removed by beating with a stick if the hair side is involved; the frost that is on the skin side of a garment is usually removed by scraping with a knife.

As said, about the only improvement on Eskimo clothing has been the snow shirt (snow coat) and trousers. The only

considerable improvement on technique is that you might carry a whiskbroom which would remove more easily than a knife the frost that gathers on smooth surfaces. A broom is also pretty good for removing frost that is in hair or fur, although beating with a stick is best—the snow flies out as dust flies when you beat a carpet.

A little hoarfrost may remain on the skin side and the hair side of your outer garments. The best thing, then, is to see to it that they do not thaw out during the night. You can do that by leaving them outside, which is best if there is no danger such as from dogs; if you feel you have to take them into the house for safety, then you slip them underneath your bedding, which must be so thick that it completely insulates the snow beneath from what is going to be the considerable warmth of the interior of your tent or snowhouse.

PROCEDURE WITH SLEEPING BAG

This description of technique is based on Eskimo methods as practiced on the Stefansson expeditions. Had his men slept in their clothes, as did Nansen and Johansen, they, too, would have had trouble. For if there are, say, 10° of frost on the bed platform and if you are dressed in fur underwear inside the sleeping bag, the invisible perspiration will condense either on the outside of your underwear or on the inside of the bag. In either case, when you turn over in your sleep, you will melt some of this hoarfrost and that will make you wet. Accordingly, the way to keep dry is to sleep naked.

Stefansson's men tried very light pajamas in the sleeping bags and found they added nothing to comfort under the best of conditions, while under the worst conditions they imprisoned enough body heat so that the condensation point for invisible perspiration was reached inside the bag, resulting in hoarfrost, followed by liquid moisture and stiff freezing in their turn.

We now come to the above-mentioned point, that the fur on the inside of a sleeping bag must be short. If the hair is a half inch long or more there are two bad results—the sleeping bag is too warm, so that liquid perspiration (sweat-

ing) is produced; and the invisible perspiration condenses in the roots of the hair.

If you sleep in a thin reindeer bag, most of the invisible perspiration does not become visible until after it has actually left the bag, so that it ascends as a kind of steam to the roof and condenses against the snow, where it sticks. A little may form on the outside of the bag and this will melt if you turn over in your sleep, but there is at all temperatures a certain amount of evaporation and this occasional slight dampening does not aggregate enough to make and keep the bag wet.

It will happen that a portion of the sleeping bag becomes slightly wet. If you see to it that the section frozen stiff is on top of you when you go to sleep, it nearly always dries so that next day there is no stiffness. If the wetting is more than ordinary, take off your clothes soon after camping, get into your bag, and spend that many more hours in it. After a few campings the bag will be dry.

SOLUTION 2

The preceding solution depends upon the careful removal of more than 90 percent of the hoarfrost when you undress at each camping, and an arrangement to make the remaining 10 percent evaporate. Peary developed a solution which relies on making all the hoarfrosts first melt and then evaporate.

Practically every man who traveled with Stefansson has testified that he enjoyed himself from day to day and never had any hardships. Peary's men, of similar caliber, have nearly or quite all said or intimated that their journeys were unpleasant. The chief answer is that Peary's solution, though simple and nearly foolproof, leads to much discomfort.

Peary carried no sleeping gear except bedding, the men sleeping on top of it in full wearing apparel. The only modification was that sometimes they had night socks—they took off their boots and stockings, most or all layers of which had become wet, wore the bedsocks, and dried the day socks by putting them next to their skin inside their clothes for the night.

If you wear the same clothes day and night it seems, from Peary's experience, that you can more or less balance the hoarfrost accumulation by drying. You have, then, the advantage of carrying no sleeping bags. But there are disadvantages: the loss of strength from unsound sleep and from discomfort is considerable; men have to eat more food to counterbalance physiologically the loss through chill; outer garments will always contain a certain amount of hoarfrost, so that they are both heavier and less warm.

The saving in weight by the Peary method is, therefore, apparent only. The saving in bulk is real, and the saving in handling. The main advantage, as said, is that the plan is nearly foolproof.

c. Procedure When Traveling

On the road you keep the formation of hoarfrost in the clothes to a minimum through preventing the ordinary visible perspiration that results from physical activity and warm clothing. The method, as practised by Stefansson and his men during thousands of miles of travel in cold weather, is one of regulation of temperature by adjustment of clothing:

On a very cold morning, when breaking camp, the traveler will wear the full outfit of three layers, except that occasionally a man will work with one or both hands bare for a few minutes at a time, the mittens, or the one not in use, hanging by a string that passes over his shoulders.

STANDARD ARRANGEMENT OF CLOTHING

As explained earlier, the coat and shirt are not tucked into the top of the trousers; they hang loose except that they are kept in at the waist by a belt which probably is outside the outer fur coat, leaving the snow shirt unrestrained. The shirt, coat, and snow shirt come about halfway to the knee.

On the road, after half an hour of rapid going, the traveler begins to feel too warm, no matter how cold the weather. The first adjustment for coolness, and to prevent wetting by perspiration, will be to remove the belt so that a certain amount of chill can come up around his body, naked from the waist. So far as this chill comes up it is agreeable; but

it does not come up much because of cold air being heavier than warm.

The coat and shirt are loose at the neck. Therefore the next cooling step may be to pull the coat forward at the neck to make an air channel all the way down from the throat. Cold air will then begin to flow down over the front of the body, which again feels most agreeable if you are overheated. By now you are probably walking barehanded, both mittens hanging suspended by their cord.

On growing still warmer, you stop the sledge to take off your outer skin pants, wearing now just the drawers and snow pants. The next step (not necessitating a stop for you can manage while walking) is to remove your outer skin coat, wearing now the shirt and snow shirt. If this is a little cool, as it may be, you put on your belt again.

If in a little you begin to feel warm even so lightened, you take off the snow pants and snow shirt, walking now in just your underwear. It does occur at even $-40°$ and $-50°$, with no wind blowing, that you wear nothing but underwear much of the day, putting on outer clothing, however, any time you stop to rest or when you stop to camp.

You must never decrease the amount of foot protection, for several reasons. Your feet are particularly liable to freeze; or, rather, freezing of the feet is particularly serious. You can always tell when any other part of your body approaches the freezing point, but you may not be able to tell with your feet because they are so encased. It would, moreover, be particularly disastrous to lose foot garments which you had taken off, for they are much more difficult to replace than other garments. For instance, if you lose a mitten you can wrap something around your hand or walk with your hand inside your shirt; if you lose footgear, you are up against it.

RE-CLOTHE IMMEDIATELY AT CAMPTIME

Important, if the day is very cold, is to put on the moment you stop most or all the garments you have shed during the day. There have been cases of travelers who allowed themselves to get so chilled that, through numbness, they finally needed help to put on their outer clothing. This is careless-

ness; for, of course, the chill and numbness come on very gradually.

SHORT-CUTS

There are several dodges for cooling which may be applied at any stage of the above adjustment. One important thing to remember is that, if you chill any part of the body, the coolness extends to other parts and more or less all over you. Cooling on this principle is started in the morning when you first begin to walk with one or both hands bare. Even while your hands are warm enough to be supple and free from numbness, they are still chilled enough so that the effect passes up your arms and apparently affects the temperature of the whole upper part of your body—perhaps the temperature of the whole body, through a slight cooling of the blood, which no doubt takes place chiefly near the surface.

Your next step on the "cool a part and you cool the whole" principle is to throw your hood back, letting it rest so that it still covers your ears, giving the effect of a high fur collar. (Ears are so susceptible to frost that they must never be left uncovered for long on a cold day, no matter how warm you feel.) Hoarfrost will form in your hair from invisible perspiration of the scalp, but you can shake most of it out if you want to resume your hood or if you are about to go indoors.

A very effective and convenient way of cooling off is to walk bare-kneed, something like a Scot in kilts. The chief reason for preferring long boots and short trousers to short boots and long trousers is that if you separate boots and trousers at the ankle you get snow on your bare skin, but under ordinary conditions you can separate them at the knee without this trouble. Usually you walk with just an inch or two of space between trousers and footgear, but if necessary you can widen this space by folding down the upper part of the footgear or by turning up a cuff on your breeches.

DAMP GARMENTS

Ordinarily none of these adjustments are made perfectly—you are likely to have perspired a little before making them unless you are very watchful and have little else to occupy you. Undergarments that become slightly damp from per-

spiration will very likely dry during the day; if not, they will dry in the evening while you are in camp sitting around and waiting for supper.

WET GARMENTS

If a garment gets very wet from excessive perspiration, you must dry it practically as described for drying a coat after you have fallen into water. You just have to sit with it on in camp until it is dry, devoting yourself to that as long as necessary, perhaps through two or three successive evenings.